2019-2050 Bay Area Seaport Forecast

Draft Final

Prepared for
SF Bay Conservation and Development Commission

The Tioga Group ♦ Hackett Associates

June 17, 2019

Table of Contents

Exhibits

Note to Reviewers

This draft final forecast has been prepared on an accelerated schedule to meet the needs of BCDC and the Seaport Planning Advisory Committee, and to assist in timely evaluation of proposed Seaport Plan amendments.

While this draft incorporates a great deal of port and industry input, the consultant team anticipates a need to refine the analysis, update the data, and reconcile any inconsistencies with the help of the Committee and interested stakeholders.

Accordingly, all analysis, findings, and conclusions should be considered draft, and subject to change or revision in the final version.

I. Executive Summary

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Executive Summary

Overview

The *San Francisco Bay Area Seaport Plan* (Seaport Plan), prepared by the San Francisco Bay Conservation and Development Commission (BCDC), guides the development and use of the Bay Area's seaport land. The Seaport Plan focuses on the lands designated for "port priority use" in the *San Francisco Bay Plan*. The general goal of the Seaport Plan is to ensure that the Bay Area retains sufficient seaport capacity to serve its foreseeable waterborne cargo needs. The Seaport Plan covers five generic cargo types:

- Containerized cargo
- Roll-on/Roll-off (ro-ro) cargo (formerly classified as "neo-bulk")
- Dry bulk cargo
- Break-bulk cargo (not currently handled)
- Non-petroleum liquid bulk cargo

The composition of SF Bay Area cargo flows has changed over time, and will continue to shift in response to demand, trade conditions, and competitive alternatives. Exhibit 14 shows the commodities moving through Bay Area ports as of early 2019.

Exhibit 1: Current 2019 Bay Area Cargo Flows

Commodity	Seaport Plan Public Ports					Private Terminals	
	Oakland	Richmond	Benicia	Redwood City	San Francisco	Levin Richmond	Others
Containerized Imports	X						
Containerized Exports	X						
Containerized Domestic IB	X						
Containerized Domestic OB	X						
Import Autos		X	X		X		
Export Autos		X	X		X		
Export Scrap Metal	X(1)			X		X(2)	
Import Veg Oils		X					
Import Chemicals							X
Import Gypsum				X			X
Import Cement				X	X		
Export Pet Coke			X			X	
Export Coal						X	
Import Sand & Gravel				X	X		X
Harvested Bay Sand				X	X		
Import Slag				X			
Import Bauxite				X			

(1) Schnitzer Steel (2) From SIMS Richmond

This report provides 30-year forecasts for the relevant cargo types, and a high-level review of marine terminal capacity and expansion outlook. Future volume through Bay Area seaports will be determined by economic activity in the Bay Area itself, and in the broader Central and Northern California market. Available near-term forecasts identified in this section share a common view that the pace of growth in California over the coming three to five years will be at a reduced pace, and that the West Coast in general will grow at a slower pace than the rest of the nation. The limited number of long-term forecasts available tend to focus on population, and depict steady growth over the long term, but at a slower rate than previously seen in California.

Containerized Cargo

The previous containerized cargo forecasts prepared for BCDC were developed by Tioga in 2009 to assist BCDC in evaluating the proposed use of Richmond's Port Potrero site for ro-ro cargo rather than for containers. That forecast was prepared toward the end of the 2008-2009 recession, and reflected widespread expectations for a relatively strong recovery. Post-recovery trade growth deviated from those expectations.

Container Cargo Forecast. The international TEU forecasts for imports and exports are driven by projections of economic growth developed by Moody's and Caltrans, including sub-components of national-level Gross Domestic Product, industrial output, and Gross Metro Product. The moderate growth scenario assumes that:

- Trade disputes are resolved, and most trade flows return to their recent growth patterns;
- Exporters affected by trade disputes either regain those former markets or find new markets;
- Long term exports rebound as foreign markets recover economically;
- Refrigerated container trade grows due to the development of the recently completed Cool Port facility at the Port of Oakland; and
- Imports of automobile parts increase as Tesla increases production.

Exhibit 2 shows the elements of the moderate growth container cargo forecast. The slow growth and strong growth scenarios have alternative assumptions documented in the report. The empty TEU forecast is built upon the loaded TEU forecast and the concept that the volume of empty containers is related to the volume of loaded containers moving in the opposite direction. Domestic container volumes between the Port of Oakland and Hawaii are more opaque, and likely are driven primarily by market share shifts than economic growth.

Exhibit 2: Port of Oakland Moderate Growth Containerized TEU Forecast, 2010-2050

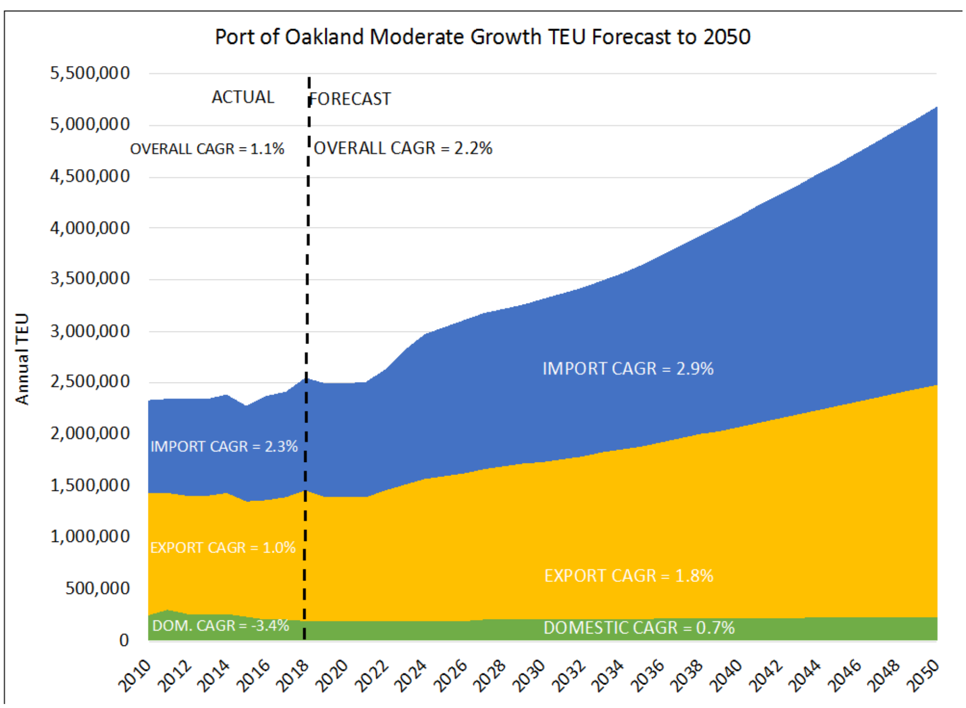
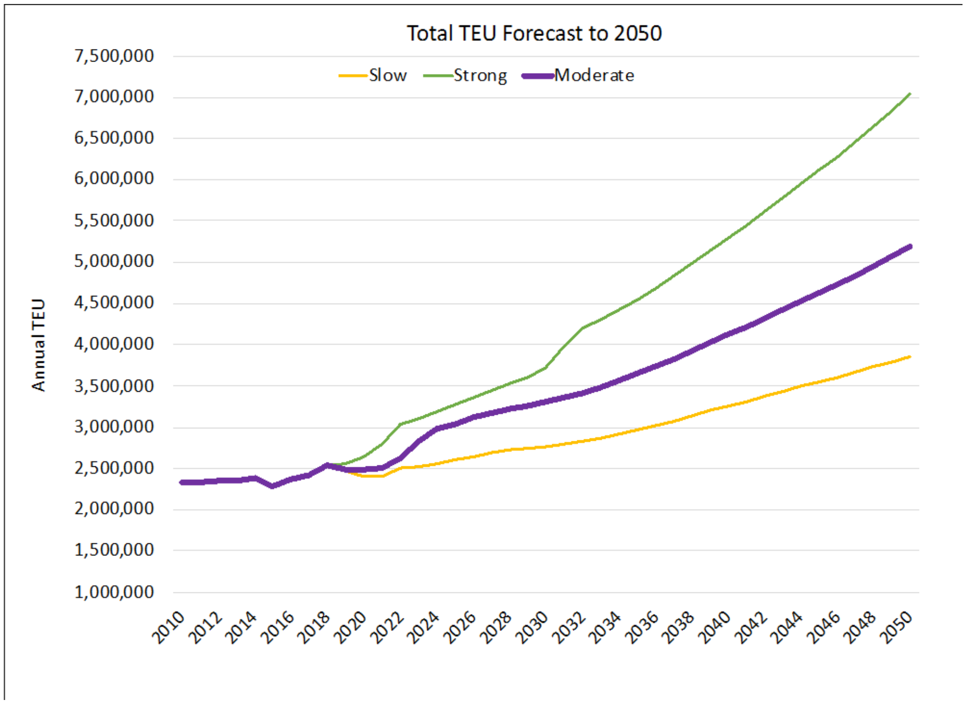


Exhibit 3 displays the three TEU forecast scenarios.

Exhibit 3: Total TEU Forecast to 2050



Container Terminal Capacity. Exhibit 87 shows the Port of Oakland's acreage in terminals and major off-dock parcels. The post-electrification acreages allow a two-acre battery exchange complex or equivalent to support zero-emissions container handling equipment.

Exhibit 4: Port of Oakland Terminals and Acreages

Terminal	Acres	2019 Acres in Use	Available Acres	Build-out Acres	Post-Electrification Acres
Ben Nutter	77	77	0	97	95
Berths 33-34	20		20		
OICT 55-56	120	120	0	290	288
OICT 57-58	150	150	0		
OICT 60	20	20	0		
TraPac	123	123	0	123	121
Matson	75	75	0	95	93
Roundhouse	20		20		
OHT Berths 20-24	150		150	150	148
Howard	50		50	50	48
Subtotal	805	565	240	805	196
Off-Dock	126	30	96	0	0
Total	931	595	336	805	196

The consultant team estimated maximum current capacity at 6,061 annual TEU per acre based on current OICT performance, and long-term capacity at 7,112 annual TEU per acre based on achieving high productivity in line with industry benchmarks. Container terminals can be expected to expand horizontally where possible, and then invest in productivity improvements to accommodate further cargo growth.

Ancillary Service Needs. As of early 2019, there were approximately 314 acres of land in the immediate Port area either already in an ancillary use (e.g. Cool Port or the two facilities on Union Pacific Land); under development for an ancillary use (e.g. Center Point Phase 1 or Prologis Buildings 2 and 3); or available for long-term ancillary use. Estimated acres required for all ancillary uses range from 167 in the slow growth scenario to 269 in the strong growth scenario. These comparisons suggest that there is adequate space within the Port of Oakland complex, including Port, City, and Union Pacific land, for the identified ancillary services to support projected cargo growth in all three scenarios.

Container Cargo Growth vs. Terminal Capacity. Exhibit 92 shows that the Port of Oakland would be at or near capacity under the moderate growth forecast and with estimated maximum terminal capacity under high productivity assumptions. If both Howard and Berths 20-21 were withdrawn from container cargo use, the port would be slightly over capacity by 2050. The slow growth forecast would leave Oakland at 70%-76% of capacity by 2050, while the strong growth forecast would exceed the port's estimated maximum capacity by 27% to 39%.

Exhibit 5: Container Cargo Growth Versus Terminal Capacity

Estimated Sustainable Capacity at:	Phase VI: High Productivity at all Terminals	2050 Moderate Growth TEU and Maximum Capacity Utilization		2050 Slow Growth TEU and Maximum Capacity Utilization		2050 Strong Growth TEU and Maximum Capacity Utilization	
815/803 Acres	5,625,797	5,187,588	92%	3,862,435	69%	7,038,560	125%
775/763 Acres w/o Howard	5,341,307	5,187,588	97%	3,862,435	72%	7,038,560	132%
795/783 Acres w/o Berths 20-21	5,483,552	5,187,588	95%	3,862,435	70%	7,038,560	128%
755/743 Acres w/o Howard or Berths 20-21	5,199,062	5,187,588	100%	3,862,435	74%	7,038,560	135%

To facilitate comparisons between cargo types, Exhibit 93 shows terminal acres needed and available under the maximum productivity assumption.

Exhibit 6: Container Cargo Growth and Acreage Requirements

Container Terminal Acres	2050 Acres Available	Moderate Growth		Slow Growth		Strong Growth	
		Required	Reserve	Required	Reserve	Required	Reserve
All Terminals	803	729	74	543	260	990	(187)
Without Howard	743	729	14	543	200	990	(247)
Without Berths 20-21	773	729	44	543	230	990	(217)
Without Howard or Berths 20-21	723	729	(6)	543	180	990	(267)

Berth Requirements. Container vessel size and the associated need for greater berth length are both increasing. The consultant team developed multiple scenarios for future vessel sizes and vessel calls, and checked their implications for berth length. Under a moderate growth scenario existing active berths could accommodate vessel growth through 2050, although some terminals would be berth-constrained on specific weekdays (also true of the slow growth scenario). Under the strong growth scenario Oakland would need additional berth capacity at either Howard or Berths 20-21. Howard's berth capacity may, however, be truncated in the process of expanding the Inner Harbor Turning Basin.

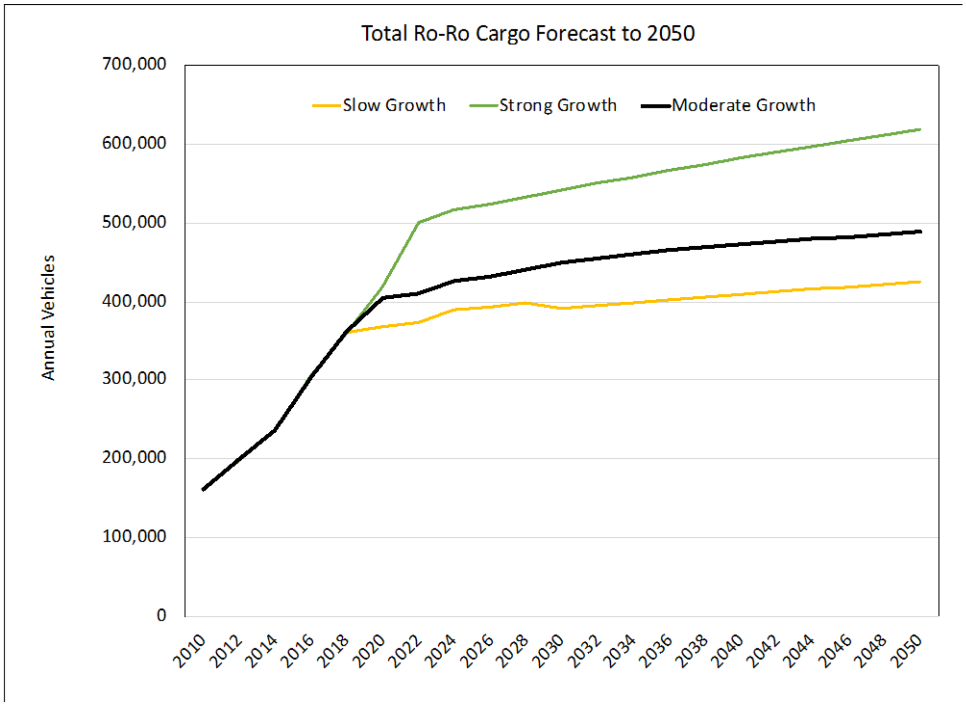
Ro-Ro (Neo-Bulk) Cargo

The Seaport Plan has used the term "neo-bulk" to describe cargos that are neither containerized nor bulk, but do not require the traditional piece-by-piece handling of break-bulk cargo. Roll-on roll-off (ro-ro) shipment of autos and other vehicles has come to dominate this cargo segment, and is the only active "neo-bulk" category at SF Bay

Area ports. The analysis therefore uses the "ro-ro" nomenclature for clarity and consistency with industry terminology.

The outlook for ro-ro cargo through San Francisco Bay depends on the growth in import and export auto volume, and on how many vehicles can be stored, processed, and moved through Bay Area facilities. The compound annual growth rate between 2019 and 2050 is projected to be 1.0 % in the moderate growth scenario, 0.5% in the slow growth scenario, and 1.8% in the strong growth scenario (Exhibit 7).

Exhibit 7: Ro-Ro Cargo Forecast to 2050



The Ports of Richmond, Benicia, and San Francisco are currently handling import and export autos in ro-ro vessels. Exhibit 155 shows that existing ro-ro terminals total about 215 acres, which compares closely to the estimate of 212 acres required under the team's base productivity estimates. This comparison is also consistent with the observations by port officials that the Richmond and Benicia terminals are operating at or near capacity at present.

Exhibit 8: Bay Area Ro-Ro Terminals and Scenario Capacities

Terminal	Acres	Low Capacity	Base Case Capacity	High Capacity
Annual Units per Acre		**1,371**	**1,700**	**2,173**
Existing	215	294,859	365,500	467,146
Benicia	75	102,858	127,500	162,958
Richmond Pt. Potrero	80	109,715	136,000	173,822
SF Pier 80	60	82,286	102,000	130,366
Potential	103	141,258	175,100	223,795
SF Pier 96	53	72,686	90,100	115,157
Oakland Howard Terminal	50	68,572	85,000	108,639
Total	**318**	**436,117**	**540,600**	**690,941**

The table in Exhibit 154 displays the combined ro-ro forecast and capacity analysis. Nine scenario combinations are presented. The moderate growth forecast and base case productivity scenario together suggest that 288 acres of ro-ro terminal space would be required to handle 488,768 vehicles in 2050, and about 73 new acres of ro-ro terminal space would be needed. The slow growth scenario would require about 35 news acres with base case productivity. The strong growth forecast would require 148 acres of new space under the base case productivity, or 69 new acres with higher productivity.

Exhibit 9: Ro-Ro Cargo Summary

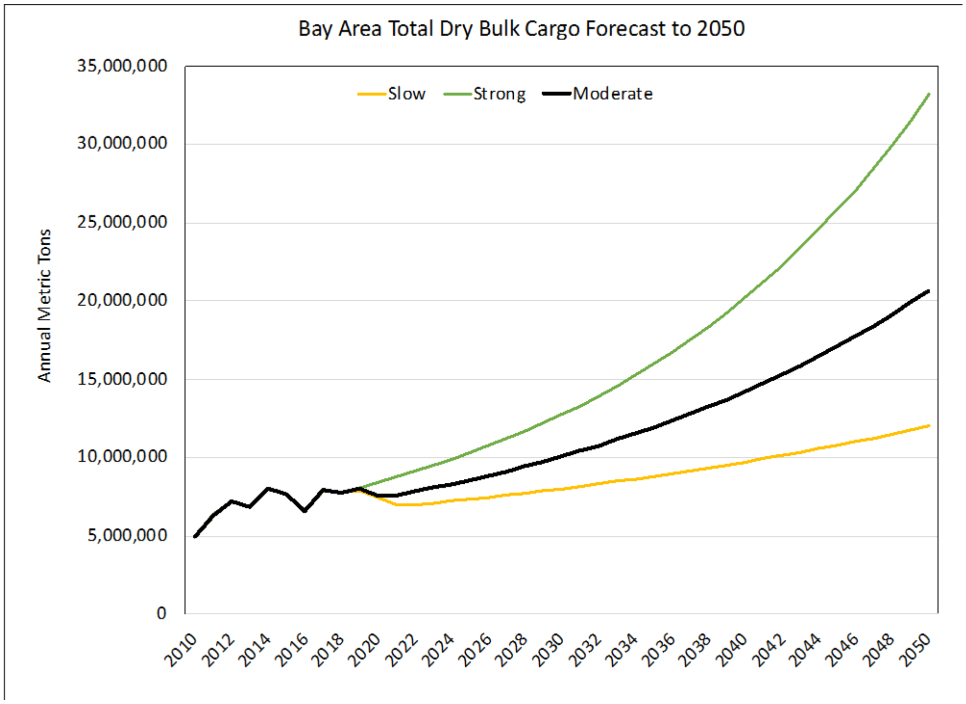
Scenario	2018	2020	2030	2040	2050	Existing Acres	New Acres	CAGR
Slow Growth	**360,671**	**368,207**	**390,388**	**409,298**	**424,892**			**0.5%**
Low Prod. Acres	212	224	285	298	310	215	95	1.2%
Base Prod. Acres	212	217	230	241	250	215	35	0.5%
High Prod. Acres	212	208	180	188	196	215	(19)	-0.3%
Moderate Growth	**360,671**	**404,607**	**448,696**	**472,768**	**488,768**			**1.0%**
Low Prod. Acres	212	247	327	345	356	215	141	1.7%
Base Prod. Acres	212	238	264	278	288	215	73	1.0%
High Prod. Acres	212	228	207	218	225	215	10	0.2%
Strong Growth	**360,671**	**418,831**	**541,505**	**582,249**	**617,923**			**1.8%**
Low Prod. Acres	212	255	395	425	451	215	236	2.5%
Base Prod. Acres	212	246	319	342	363	215	148	1.8%
High Prod. Acres	212	236	249	268	284	215	69	0.9%

Dry Bulk Cargo

The dry bulk import cargos handled through Bay Area ports have long been dominated by construction industry needs. The major commodities have included, and continue to include, aggregates (sand and gravel), bauxite and slag (used as concrete additives), and gypsum (used in wallboard). Outbound dry bulk cargos include scrap metal, petroleum coke (pet coke, a refinery by-product), and coal.

Dry Bulk Forecast. Exhibit 177 displays the combined tonnage forecast for dry bulk commodities, including imports, exports, and harvested bay sand. The main drivers are demand for sand and gravel and a dwindling regional supply, leading to increased imports.

Exhibit 10: Bay Area Total Dry Bulk Cargo Forecast, 2010-2050



Dry Bulk Capacity. The current (2012) Bay Area Seaport Plan includes a requirement of 13 acres for a dry bulk terminal and an average throughput capability of 1,037,000 metric tons per berth. The productivity forecast utilizes a spectrum of efficiency improvements that increase the number of metric tons handled per acre at varying rates by scenario, either by gradually introducing denser storage or by moving the product through the terminal and out to the customer faster. Exhibit 195 combines these productivity scenarios to estimate terminal requirements under moderate, slow, and strong growth forecasts. Moderate growth would likely require the equivalent of 34 additional acres and 3 additional berths.

Exhibit 11: Bay Area Estimated Dry Bulk Terminal Requirements for 2050

Factor	Existing	Moderate Growth	Slow Growth	Strong Growth
Annual Metric Tons	7,862,461	20,654,542	12,025,443	33,183,607
Tonnage increase	na	144%	47%	281%
Acres	**166**	**200**	**189**	**239**
MT/Acre	47,507	103,500	63,638	317,073
Acres per Terminal	13.8	13.8	13.4	14.9
Teminals	**12**	**15**	**14**	**16**
MT/Berth	655,205	1,423,120	846,103	2,402,750
Berths	**12**	**15**	**14**	**16**
New Acres		**34**	**23**	**73**
New Berths		**3**	**2**	**4**

Other Cargo Types

Bay Area Seaport facilities at Richmond continue to handle some non-refinery liquid bulk cargo including imported vegetable oils and chemicals. These are single-purpose terminals, however, and most are under private ownership. Cargo movements may rise or fall on a commodity-by-commodity basis without strong long-term trends. Accordingly, the consultant did not analyze these flows or terminals in detail.

Some Bay Area seaport terminals previously handled break-bulk or project cargo. None handle such cargoes at present, and there is no specific projection for future demand. As the need for break-bulk or project cargo shipments (e.g. windmill parts) could arise in the future, there may be a purpose in maintaining break-bulk capability for the Bay Area, perhaps within container or ro-ro terminals.

Summary Findings

The Bay Area's seaports can expect long-term cargo growth in three sectors that could stress capacity: containerized cargo, ro-ro vehicle cargo, and import dry bulk cargo. There are three basic strategies for accommodating the expected growth: increased throughput at existing facilities; horizontal expansion onto vacant land or land in other uses within seaport complexes; and use of dormant marine terminals.

Increased throughput at existing terminals is generally the least costly, most efficient, and least disruptive means of accommodating growth. Terminal operators can be expected to expand throughput to the point at which the terminal becomes congested or when substantial capital investment is needed to increase capacity. At that point, economic and financial tradeoff will determine the preferred expansion path. Horizontal expansion onto available seaport land is often less costly and easier to implement than expansion via capital investment or existing footprints.

Exhibit 199 provides estimates of total seaport terminal acreage requirements under the three forecast scenarios. There are many possible variations. The three cargo types will not necessarily follow similar growth scenarios, although all will be affected by the same underlying regional economic growth trends. Also, different terminals may follow different productivity strategies. The general implication of Exhibit 199, however, is clear:

- Under moderate cargo growth assumptions the Bay Area will need more active terminal space, estimated at about 271 acres by 2050.
- Under slow cargo growth assumptions the Bay Area will need about 36 acres more active terminal space by 2050.
- Under strong growth across the three cargo types, the Bay Area will need substantially more seaport terminal space, about 646 more acres than is now active (and will need to activate additional berth space for larger container vessels).

Exhibit 12: Estimated Seaport Acreage Requirements

Forecast Scenario	Container Cargo Terminal Acres			Ro-Ro Cargo Terminal Acres			Dry Bulk Cargo Terminal Acres			Combined Cargo Terminal Acres		
	Existing*	2050**	Additonal	Existing	2050***	Additonal	Existing	2050***	Additonal	Existing	2050	Additonal
Moderate Growth	565	729	164	215	288	73	166	200	34	**946**	**1,216**	**271**
Slow Growth	565	543	(22)	215	250	35	166	189	23	**946**	**982**	**36**
Strong Growth	565	990	425	215	363	148	166	239	73	**946**	**1,592**	**646**

* In-use Acreage at Port of Oakland

** At maximum mainstream productivity

** *Under base productivity assumptions

Available Terminal Expansion Sites

Within the Bay Area seaports there are a few dormant or under-utilized terminal sites.

- San Francisco's Pier 96, formerly part of the Pier 94–96 container terminal, is currently partially vacant and partially in non-cargo uses.
- Oakland's Berth 20-21area is used for ancillary services at present, although there is an active proposal to develop a dry bulk terminal there.
- Oakland's Berth 22-24 area, formerly part of the Ports America complex, is currently used for ancillary port functions.
- Oakland's Howard Terminal is also currently used for ancillary services.
- Oakland's Roundhouse parcel, although not on the water, is adjacent to active container terminals.
- Richmond's Terminal 3, formerly a small container terminal, is currently being used to load logs into containers for export through Oakland, but is not handling any cargo over the wharf.

Exhibit 200 lists these sites, their size, and their potential uses. The table also illustrates some inherent tradeoffs.

Exhibit 13: Bay Area Seaport Expansion Sites

Site	Acres	Potential Use		
		Container	Ro-Ro	Dry Bulk
SF Pier 96	50		X	X
Oakland Berths 20-21	23	X		X
Oakland Berths 22-24	130	X		
Oakland Berths 33-34	20	X		
Oakland Roundhouse	39	X		
Oakland Howard*	38	X	X	X
Richmond Terminal 3	20		X	X
Available Acres	**320**	**189-250**	**0-108**	**0-131**
Moderate Growth Needs	271	164	73	34
Slow Growth Needs	36	-22	35	23
Strong Growth Needs	646	425	148	73

* Post turning basin expansion

- San Francisco's Pier 96 was most recently used to handle containers. Its limited draft, however, would make it less suitable for container handling than the Oakland locations. Moreover, the container shipping industry previously consolidated at the Oakland terminals, and an isolated terminal across the Bay at San Francisco is unlikely to be attractive to container shipping lines in the future. Pier 96 also lacks access to active rail intermodal facilities. Trucks connecting Pier 96 with inland customers would add to congestion on the bay bridges. Pier 96 would therefore most likely be suitable for ro-ro or dry bulk cargos.
- Oakland's Berth 22-24 site is expected to be used for container cargo in the long run. The consultant team's analysis suggests that the Berth 22–24 capacity will be required under any container forecast scenario, and there have been no proposals to use this space for other cargos.

- Oakland’s Berths 20-21 may be used for dry bulk cargo, either as an interim use or in the long term. If so, available container berth space would be reduced as well, increasing the need to either boost productivity or expand container operations to Howard Terminal.
- Oakland's Roundhouse site has no berth access, and can only function as added space for adjacent container terminals.
- Oakland’s Howard Terminal capacity may be required for container handling under the forecast scenarios, depending on what degree of other productivity improvement is implemented at other terminals. In addition to its terminal acreage, Howard's berth capacity may be required to handle larger vessels or additional services under a strong growth scenario, particularly if Berths 20-21 are used for dry bulk cargo. Howard Terminal may also be a logical expansion site for ro-ro vehicle handling. Howard has handled ro-ro vehicles in the past, and is the closest marine terminal to Tesla’s Fremont assembly plant. Howard could also handle dry bulk cargo under some circumstances, and Schnitzer Steel has expressed interest in using a portion of Howard to expand its adjacent operations.
- Richmond’s Terminal 3 has limited space, as the terminal totals about 20 acres. With such limited backland, 35’ of draft, and isolation from the Oakland terminals, T3 is not a viable location for container handling. T3 would most likely serve as auxiliary parking for the Pt. Potrero ro-ro terminal. It could also handle dry bulk cargos.

As Exhibit 200 indicates, moderate container cargo growth through 2050 could probably be handled at Oakland without Howard Terminal or Berths 20-21, but as Exhibit 92 shows Oakland would have little or no room for future growth. Strong container cargo growth would exhaust Oakland's total capacity unless terminals can boost productivity to higher levels than anticipated.

The Bay Area could probably meet moderate ro-ro cargo growth needs at SF Pier 96 and Richmond's Terminal 3, but strong growth would introduce a conflicting demand for Howard Terminal's acreage.

Dry cargo growth may conflict with the availability of SF Pier 96, Oakland's Berth 20-21, or Howard Terminal for ro-ro or container cargo.

II. Introduction

The *San Francisco Bay Area Seaport Plan*, prepared by the San Francisco Bay Conservation and Development Commission (BCDC), guides the development and use of the Bay Area's seaport land. The Seaport Plan focusses on the lands designated as "port priority use". The Seaport Planning Advisory Committee (SPAC), composed of industry and planning agency representatives, oversees Seaport Plan development and updates.

The general goal of the Seaport Plan is to ensure that the Bay Area retains sufficient seaport capacity to serve its foreseeable waterborne cargo needs. To do so, the Seaport Plan must be periodically updated to reflect the best available information on expected cargo growth and marine terminal capacities. Waterfront land is a finite resource, and selected portions have been designated seaport priority use. Most of that land is already being used to handle waterborne cargo, and there are only a few sites idle or developable to handle cargo growth.

The Seaport Plan covers five generic cargo types:

- Containerized cargo.
- Roll-on/Roll-off (ro-ro) cargo (formerly classified as "neo-bulk").
- Dry bulk cargo.
- Break-bulk cargo (not currently handled).
- Liquid bulk cargo (of specific types)

Liquid bulk cargos consist primarily of crude petroleum, petroleum products, chemicals, and other commodities handled at specialized private marine terminals, and are outside the Seaport Plan scope.

The container cargo forecast and terminal capacity estimates were last updated in 2009, and the bulk cargo forecast was last updated in 2011. While some of the trends documented in those updates have continued, there have since been numerous shifts in both economic development and trade conditions since.

This report provides 30-year forecasts for the relevant cargo types, and a high-level review of marine terminal capacity and expansion outlook. The approach taken was cargo-specific and commodity-specific, as opposed to applying a high-level econometric forecast. Bay Area seaports handle containerized cargo and just a few other commodities, and as the trends discussion documents these flows respond to a variety of outside factors. This report also examines the need for ancillary services to support the full functionality of container terminals, and the land requirements of those services.

Current Cargo Flows

The composition of SF Bay Area cargo flows has changed over time, and will continue to shift in response to demand, trade conditions, and competitive alternatives. Exhibit 14 shows the commodities moving through Bay Area ports as of early 2019.

Exhibit 14: Current 2019 Bay Area Cargo Flows

Commodity	Seaport Plan Public Ports					Private Terminals	
	Oakland	Richmond	Benicia	Redwood City	San Francisco	Levin Richmond	Others
Containerized Imports	X						
Containerized Exports	X						
Containerized Domestic IB	X						
Containerized Domestic OB	X						
Import Autos		X	X		X		
Export Autos		X	X		X		
Export Scrap Metal	X(1)			X		X(2)	
Import Veg Oils		X					
Import Chemicals							X
Import Gypsum				X			X
Import Cement				X	X		
Export Pet Coke			X			X	
Export Coal						X	
Import Sand & Gravel				X	X		X
Harvested Bay Sand				X	X		
Import Slag				X			
Import Bauxite				X			

(1) Schnitzer Steel (2) From SIMS Richmond

- The Port of Oakland itself handles containerized cargo almost exclusively. The exception is a small volume of non-containerized autos handled by Matson.
- Schnitzer Steel, a private terminal within the Oakland Harbor but not part of the Port of Oakland, exports scrap metal in bulk.
- The Port of Richmond handles autos in ro-ro service at its Point Potrero terminal and vegetable oil imports at the AAK terminal. The Port’s Terminal 3 is being used to stage and containerize logs that are then exported through the Port of Oakland. It is anticipated that these logs may eventually be handled in break bulk service directly from Richmond.
- The Benicia Port Terminal Company (BPTC), at Benicia, handles autos and trucks in ro-ro service (predominantly imports). BPTC is developing a supplementary terminal at Pittsburg, beyond the Seaport Plan Scope. BPTC also exports petroleum coke in bulk from the nearby refinery.
- The Port of Redwood City is currently exporting scrap metal in bulk and importing sand and gravel, slag, bauxite, and gypsum in bulk. Redwood City also receives bay sand.
- The Port of San Francisco is currently handling autos in ro-ro service (primarily Tesla exports) at Pier 80, import aggregates at Pier 94, and harvested bay sand at two locations.
- Levin Richmond Terminal (LRT) is a private multi-purpose port facility adjacent to the Port of Richmond. LRT has handled multiple commodities in the past and is currently handling export coal and petroleum coke. LRT also handles scrap metal exports from the adjacent Sims site.
- There are private terminals handling aggregates (Eagle Rock), gypsum (National Gypsum), and chemicals at Richmond, as well as a terminal handling import vegetable oils.
- There are multiple refineries handling liquid bulk petroleum products in the Bay Area. Those terminals and commodities, however, are excluded from the Seaport Plan.

- Sand “harvested” (dredged) from the bay floor is not a “cargo” in the usual sense. Bay sand does, however, occupy port facilities, and if bay sand production declines it may be necessary to increase sand imports.

The narrowing range of cargoes and cargo types being handled at SF Bay Area ports allowed the consultant team to focus on the following demand factors:

- For international containerized trade: regional demand for imports and foreign demand for California imports.
- For domestic containerized cargo: the future of shipments to and from Hawaii, Guam, etc. and Oakland’s market share.
- Ro-Ro autos: U.S. demand for imports and foreign demand for U.S. production, specifically Teslas.
- For export dry bulks: foreign demand for scrap metal, and local refinery production of petroleum coke.
- For import dry bulks: Northern California construction activity and local supply of sand and gravel.

III. Relevant Economic and Trade Trends

(Note: this draft version contains tables and charts copied directly from their sources due to time constraints. The final report will include re-formatted graphics or citations as appropriate.)

Economic Trends

Future volume through Bay Area seaports will be determined by economic activity in the Bay Area itself, and in the broader Central and Northern California market. Some exports move through Oakland from Oregon and Nevada, and occasionally beyond. Some import flows extend from California distribution centers (DCs) to markets in other Western states, and some import containers cross the Nevada border to a distribution center in Sparks.

The primary focus of this analysis is therefore the Bay Area and Northern and Central California, but the team's analysis must also take the overall western state context into account.

Near-term Forecasts

The forecasts identified in this section share a common view that the pace of growth in California over the coming three to five years will be at a reduced pace, and that the West Coast in general will grow at a slower pace than the rest of the nation (Exhibit 15).

Exhibit 15: Near-Term Forecast Summaries

Forecast	Outlook
Governor's Budget	California growth is projected to be steady, but at a slower pace than was typical of the pre-recession years
ComericA Bank State Economic Outlook	California growth is forecast to be steady at moderate rates, although there are increased downside risks in the near term
UCLA Anderson Forecast	Statewide outlook for slower economic growth in 2019 and in coming years
Center for Business and Policy Research at the University of the Pacific Eberhardt School of Business, 2019-2022 California & Metro Forecast	Real gross state product is forecast to grow at a reduced pace as recession risks grow
City of San Jose Economic Forecast	San Jose development outlook is increasing in 2019-2023 over
Wells Fargo Western Economic Outlook	West Coast outlook remains bright but growth is anticipated to moderate relative to the rest of the country
Bank of the West California Economic Outlook	California job growth peaked in 2015 and slower growth is expected to continue through 2020 due to weaker global growth and tighter financial conditions. Bay Area job growth is held down by the low unemployment rate, meaning that fewer unemployed workers are available to fill new jobs.

Most available forecasts of economic activity cover only 1–4 years out. The value of these forecasts is establishing that no near-term changes from existing patterns are expected.

Governor's Budget Summary — 2019-20 - Economic Outlook

The Governor's Budget Summary includes a section on the economic outlook.

The indicators in Exhibit 16 compare the U.S. and California outlooks through 2022. The state forecast indicates that, from 2017 to 2022:

- Personal income will grow by 25.7% (compared to growth of 24.6% at the national level).
- Annual housing permits will increase by 55% (perhaps linked to an aggressive affordable housing policy).
- The civilian labor force will grow by 3.6% (compared to growth of 4.5% at the national level).

These projections are consistent with an overall picture of steady, but slower growth than was typical of the pre-recession years.

Exhibit 16: Governor's Budget Summary - Selected Indicators

			Forecast				
	2016	2017	2018	2019	2020	2021	2022
United States							
Nominal gross domestic product, $ billions	$ 18,707	$ 19,485	$ 20,504	$ 21,555	$ 22,537	$ 23,472	$ 24,420
Real gross domestic product, percent change	1.6%	2.2%	2.9%	2.7%	2.1%	1.6%	1.5%
Contributions to real GDP growth							
Personal consumption expenditures	1.9%	1.7%	1.8%	1.9%	1.6%	1.5%	1.3%
Gross private domestic investment	-0.2%	0.8%	1.0%	0.9%	0.6%	0.4%	0.3%
Net exports	-0.3%	-0.3%	-0.2%	-0.5%	-0.3%	-0.3%	-0.2%
Government purchases of goods and services	0.3%	0.0%	0.3%	0.5%	0.2%	0.0%	0.0%
Personal income, $ billions	$ 16,125	$ 16,831	$ 17,585	$ 18,378	$ 19,284	$ 20,131	$ 20,974
Corporate profits, percent change	-0.2%	2.4%	0.0%	6.8%	2.3%	3.2%	3.2%
Housing permits, thousands	1,207	1,282	--	--	--	--	--
Housing starts, thousands	1,177	1,208	1,263	1,318	1,424	1,435	1,437
Median sales price of existing homes	$ 235,500	$ 248,800	--	--	--	--	--
Federal funds rate, percent	0.4%	1.0%	1.8%	2.8%	3.4%	3.4%	3.4%
Consumer price index, percent change	1.3%	2.1%	2.5%	2.5%	2.0%	2.1%	2.1%
Unemployment rate, percent	4.9%	4.4%	3.9%	3.4%	3.4%	3.6%	3.8%
Civilian labor force, millions	159.2	160.3	162.0	163.5	165.3	166.4	167.5
Nonfarm employment, millions	144.3	146.6	149.0	151.3	153.0	153.8	154.5
California							
Personal income, $ billions	$ 2,259	$ 2,364	$ 2,494	$ 2,619	$ 2,740	$ 2,857	$ 2,972
California exports, percent change	-1.2%	5.2%	--	--	--	--	--
Housing permits, thousands	101	114	125	139	154	166	177
Housing unit net change, thousands	89	85	--	--	--	--	--
Median sales price of existing homes	$ 502,930	$ 537,860	--	--	--	--	--
Consumer price index, percent change	2.3%	2.9%	3.7%	3.7%	3.2%	3.0%	2.8%
Unemployment rate, percent	5.5%	4.8%	4.3%	4.3%	4.3%	4.3%	4.3%
Civilian labor force, millions	19.1	19.3	19.5	19.6	19.8	19.9	20.0
Nonfarm employment, millions	16.5	16.8	17.2	17.4	17.5	17.7	17.8
Percent of total nonfarm employment							
Mining and logging	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Construction	4.7%	4.8%	5.0%	5.3%	5.6%	5.9%	6.2%
Manufacturing	8.0%	7.8%	7.7%	7.6%	7.5%	7.5%	7.4%
Trade, transportation, and utilities	18.1%	18.1%	17.9%	17.8%	17.7%	17.7%	17.6%
Information	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%	3.1%
Financial activities	5.0%	5.0%	4.9%	4.9%	4.9%	4.9%	4.9%
Professional and business services	15.3%	15.3%	15.4%	15.4%	15.4%	15.3%	15.2%
Educational and health services	15.4%	15.7%	15.7%	15.8%	15.8%	15.9%	16.0%
Leisure and hospitality	11.5%	11.6%	11.6%	11.5%	11.5%	11.5%	11.4%
Other services	3.4%	3.4%	3.4%	3.3%	3.3%	3.3%	3.3%
Government	15.3%	15.2%	15.1%	15.0%	14.9%	14.8%	14.8%

Forecast based on data available as of November 2018.
Percent changes calculated from unrounded data.

ComericA Bank State Economic Outlook

This forecast expects the California economy to continue to expand in the near term. The forecast does note increased downside risks to California's economy, and that there are fewer possible accelerators. A resolution to the U.S./China trade war would boost demand for California exports and increase shipping volumes through California ports. Job growth is expected to be moderate. Recent declines in mortgage rates and moderating house price growth across California's major metropolitan areas are expected to help affordability in the short term.

Exhibit 17 summarizes the forecast through 1Q20. Here too, the picture is of steady growth at moderate rates.

Exhibit 17: ComericA California Outlook

		Actual		Forecast						Actual	Forecast	
		2Q'18	3Q'18	4Q'18	1Q'19	2Q'19	3Q'19	4Q'19	1Q'20	2017	2018	2019
State GDP	Real GDP (Chained 2009 Millions $)	2,652,488	2,678,432	2,702,426	2,721,884	2,740,193	2,755,797	2,767,719	2,778,408	2,576,223	2,665,519	2,746,398
	Percent Change Annualized	**3.7**	**4.0**	**3.6**	**2.9**	**2.7**	**2.3**	**1.7**	**1.6**	**3.0**	**3.5**	**3.0**
Labor and Demographics	Payroll Jobs (Thousands)	17,096	17,179	17,262	17,343	17,411	17,478	17,538	17,597	16,819	17,148	17,443
	Percent Change Annualized	**1.0**	**2.0**	**2.0**	**1.9**	**1.6**	**1.5**	**1.4**	**1.3**	**2.1**	**2.0**	**1.7**
	Unemployment Rate (Percent)	4.2	4.2	4.1	3.9	3.8	3.7	3.6	3.5	4.8	4.2	3.7
	Population (Thousands)	39,557	39,605	39,656	39,708	39,762	39,815	39,866	39,917	39,419	39,584	39,788
	Percent Change Annualized	**0.4**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.4**	**0.5**
	Net Migration (Thousands)	-9.7	-9.4	-9.5	-8.1	-8.5	-8.4	-8.6	-9.2	-31.7	-38.5	-33.7
Personal Income	Total Personal Income (Nom., Millions $)	2,465,197	2,490,789	2,521,959	2,548,972	2,578,814	2,610,955	2,642,783	2,674,075	2,364,129	2,477,807	2,595,381
	Percent Change Annualized	**5.4**	**4.2**	**5.1**	**4.4**	**4.8**	**5.1**	**5.0**	**4.8**	**4.6**	**4.8**	**4.7**
Housing	Housing Starts (Total, Ann. Rate)	117,929	111,259	109,821	110,926	111,385	111,604	111,987	112,157	103,335	117,322	111,475
	Percent Change Annualized	**-32.9**	**-20.8**	**-5.1**	**4.1**	**1.7**	**0.8**	**1.4**	**0.6**	**8.2**	**13.5**	**-5.0**
	SF Housing Starts (# of Units, Ann Rate)	66,312	66,006	64,470	65,410	65,766	65,943	66,180	66,312	59,131	67,233	65,825
	MF Housing Starts (# of Units, Ann Rate)	51,617	45,253	45,351	45,516	45,620	45,661	45,807	45,845	44,204	50,089	45,651
	Existing Home Sales (Ths. of Units, Ann Rate)	453	429	427	429	431	432	433	433	473	444	431
	House Prices, FHFA (1991 Q1=100, SA)	281	284	287	290	293	296	299	302	263	282	295
	Year/Year Percent Change	**7.5**	**6.5**	**5.7**	**4.3**	**4.6**	**4.5**	**4.2**	**4.1**	**8.2**	**7.2**	**4.4**
Bankruptcies	Total Business (12 Months Ending)	2,828	2,819	2,813	2,728	2,698	2,656	2,636	2,619	2,974	2,860	2,680
	Total Personal (12 Months Ending)	66,624	66,041	65,855	65,328	63,664	62,729	61,936	61,450	69,956	66,437	63,414

UCLA Anderson Forecast

The economic forecast for the United States (and specifically California) prepared by the UCLA Anderson project predicts slower economic growth in 2019 and in coming years.

"In his outlook for the national economy, UCLA Anderson Senior Economist David Shulman says that 'growth will gradually taper off in all of the major sectors of the economy.' While consumer spending has been strong, peaking at 4% in the second quarter, it is expected to decrease to 2% by the fourth quarter of 2019 and to 1.5% by the fourth quarter of 2020."

"In his latest essay, UCLA Anderson Forecast Director Jerry Nickelsburg says that the California forecasts for 2018 and 2019 have not changed much from the June 2018 outlook. He anticipates that California's economy in 2020 will be slightly weaker, compliments of changes in fiscal policy that also will affect the national outlook. While the state's economy has been evolving as expected, the risk of a trade war with China remains a concern, as it could adversely affect the logistics industry, one of the fastest growing sectors in California this past year."

Center for Business and Policy Research at the University of the Pacific Eberhardt School of Business, 2019-2022 California & Metro Forecast, February 2019

This forecast covers both California as a whole and selected metro areas.

- Overall, real gross state product is forecast to grow at 2.9%, and drop below 2% growth by 2021 as recession risks grow.

- A slight slowdown in construction job growth is expected in 2019, about 30,000 new jobs compared to as much as 50,000 in recent years. Job growth may be limited by worker availability and limited new residential construction in 2019. Single family housing starts are projected at 66,000 in 2019, about the same as 2018. Multi-family production is also projected to be flat in 2019 between 45,000 and 50,000 new units. After 2019, total new housing starts gradually grow another 10% and stabilize at 125,000 total per year.
- California's population growth is projected at about 0.5% for the next several years, at or near a record low growth rate. California's population is still on track to reach 40 million this year prior to the 2020 census, and should add about 200,000 new residents per year.

As Exhibit 18 shows, the Central Valley economy is expected to grow somewhat faster than in the Bay Area. One reason is that current unemployment rates are higher in the Central Valley, implying a large margin for employment growth.

Exhibit 18: 2019-2022 Metro Area Forecast Summaries

Central Valley Metro Forecast Summary

Metro Area	Non-Farm Payroll Employment (% Change)					Unemployment Rate (%)				
	2017	2018	2019	2020	2021	2017	2018	2019	2020	2021
Sacramento	2.1	2.0	2.4	2.0	1.2	4.5	3.7	3.5	3.4	3.6
Stockton	3.9	3.2	2.1	1.3	1.2	7.0	6.0	5.6	5.5	5.7
Modesto	1.7	2.0	1.5	1.1	0.7	7.5	6.3	6.1	6.2	6.4
Merced	3.3	3.5	1.9	1.7	1.4	9.3	8.1	7.7	7.8	8.1
Fresno	2.6	2.8	1.9	1.1	0.6	8.5	7.3	6.8	6.8	7.0
California	**2.1**	**1.9**	**1.5**	**1.3**	**0.7**	**4.8**	**4.2**	**4.0**	**4.0**	**4.2**

Note: Sacramento MSA includes Sacramento, El Dorada, Placer, and Yolo Counties. Stockton, Merced, Fresno, and Modesto MSAs correspond to San Joaquin, Merced, Fresno, and Stanislaus Counties

Bay Area Metro Forecast Summary

Metro Area	Non-Farm Payroll Employment (% Change)					Unemployment Rate (%)				
	2017	2018	2019	2020	2021	2017	2018	2019	2020	2021
San Francisco	2.2	1.9	2.3	2.0	0.8	2.8	2.3	2.2	2.1	2.1
San Jose	2.5	3.1	2.3	1.6	1.1	3.3	2.6	2.5	2.4	2.4
Oakland	2.3	1.9	1.3	1.2	0.8	3.7	3.1	3.0	3.1	3.2
California	**2.1**	**1.9**	**1.5**	**1.3**	**0.7**	**4.8**	**4.2**	**4.0**	**4.0**	**4.2**

Note: San Francisco MSA includes San Francisco and San Mateo Counties. Oakland MSA includes Contra Costa and Alameda Counties. San Jose MSA includes Santa Clara and San Benito Counties.

Exhibit 19 shows the state-level summary, calling for:

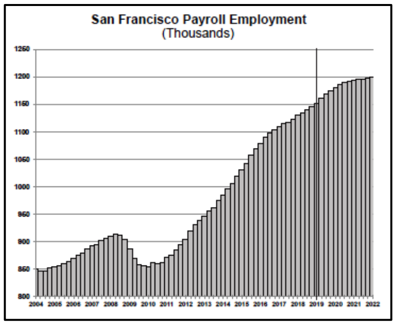
- Tapering GSP growth rates in 2020–2022.
- A gradual increase in the labor force.
- Increasing housing starts.
- Steady new vehicle registrations.

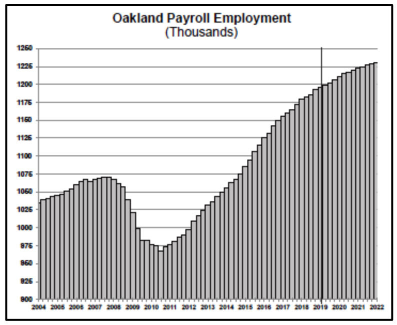
Exhibit 19: 2019-2022 California & Metro State Forecast

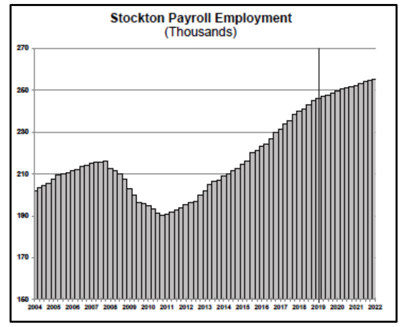
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Personal Income and Gross State Product												
Personal Income (Bil. $)	1,738	1,854	1,886	2,022	2,173	2,259	2,364	2,468	2,583	2,720	2,848	2,974
Calif. (%Ch)	6.8	6.6	1.8	7.2	7.5	4	4.6	4.4	4.6	5.3	4.7	4.4
Gross State Product (Bil. $)	2,050	2,145	2,263	2,397	2,557	2,665	2,798	2,952	3,108	3,259	3,394	3,521
Calif. (%Ch)	3.8	4.6	5.5	5.9	6.7	4.2	5	5.5	5.3	4.9	4.2	3.7
Real GSP (Bil. 2009$)	2,092	2,145	2,221	2,310	2,425	2,501	2,576	2,664	2,744	2,814	2,861	2,899
Calif. (%Ch)	1.6	2.5	3.6	4	5	3.1	3	3.4	3	2.6	1.7	1.3
Employment and Labor Force (Household Survey % Change)												
Employment	1	2.1	2.2	2.3	2.2	1.8	1.9	1.1	1.7	0.9	0.4	0.3
Labor Force	0.4	0.6	0.5	0.7	0.7	1	1.1	0.5	1.5	0.9	0.6	0.5
CA Unemployment Rate (%)	11.7	10.4	8.9	7.5	6.2	5.5	4.8	4.2	4	4	4.2	4.4
Non-Farm Employment (Payroll Survey % Change)												
Total Non-Farm California	1.1	2.2	2.6	2.8	3	2.7	2.1	1.9	1.5	1.3	0.7	0.5
Mining	8.5	6.2	-0.1	3.4	-9.6	-15.4	-1.4	0.5	1	1.2	0.8	0.7
Construction	0.2	5.1	8.1	5.8	8.5	6	4.4	5.6	2.7	4.2	5.1	3.9
Manufacturing	0.5	0.4	0.2	1.4	1.7	0.5	0.1	0.5	0.8	-0.3	-0.7	-0.1
Nondurable Goods	-0.4	0.3	0.5	1.1	1.1	1	-0.5	-1.8	0	-0.2	-0.3	0
Durable Goods	1.1	0.4	0	1.6	2.1	0.2	0.4	1.8	1.3	-0.3	-1	-0.1
Trans. Warehs. & Utility	1.8	2.7	3.2	4.1	6.2	6.7	5.5	3.7	2.2	0.1	-0.1	-0.2
Wholesale Trade	2.1	2.4	2.5	2.1	1.2	0.6	0.8	0.3	0.9	0.8	0.5	0.4
Retail Trade	1.9	1.5	1.6	2.2	2	1.1	0.8	0.5	-0.4	-0.6	-0.5	-0.8
Financial Activities	0.2	1.5	1.2	-0.1	2.5	2.6	1.1	0.5	1.5	1.7	0.2	-0.3
Prof. and Business Services	2.8	5	4.4	3.4	2.7	1.7	1.8	2.6	4.1	4.6	1.6	1.1
Edu & Health Services	1.5	3.2	3.3	3	3.6	3.5	3.8	3	1.6	0.3	0.6	0.5
Leisure & Hospitality	2.3	4.1	4.9	4.8	4.1	4	2.7	2.7	1.1	0.9	0.6	0.3
Information	0.6	1	3	3	5.2	7.8	0.5	1.9	1.9	2.1	2.3	0.8
Federal Gov't.	-4.6	-1.9	-1.9	-1.3	0.7	1.4	0.3	-1.1	-0.1	4.5	-3.5	0
State & Local Gov't.	-1.3	-1.2	0.1	2	2.2	2.2	1.7	1.4	0.6	0.5	0.6	0.6
Other Indicators												
Population (thous)	37,716	38,059	38,393	8,741	39,061	39,325	39,569	39,810	39,983	40,170	40,369	40,578
(%Ch)	0.9	0.9	0.9	0.9	0.8	0.7	0.6	0.6	0.4	0.5	0.5	0.5
Housing Starts Tot. Private (Annual Rat	45.8	56	72.6	79.2	92.5	96.5	103.5	113.3	113.2	125.6	127.4	127.4
Housing Starts Single Family	23.9	28.8	36.6	41.8	47	50.9	59.7	66.2	66	73.1	74.1	73.8
Housing Starts Multi-Family	21.9	27.2	36	37.4	45.4	45.6	43.8	47.1	47.3	52.4	53.3	53.6
New Passenger Car & Truck Registratior	1,223	1,529	1,712	1,848	2,054	2,089	2,048	1,992	2,006	1,997	1,994	1,905
Retail Sales (Billions $)	462	493	509	532	551	570	600	632	668	690	716	744

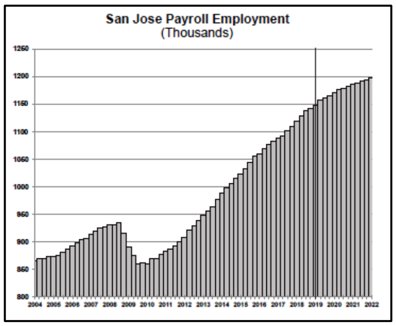
As Exhibit 20 suggests, the major metro areas in the Bay Area seaports' market area all have similar near-term employment outlooks, although from different starting points.

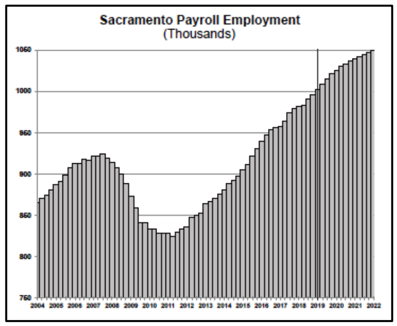
Exhibit 20: Metro Area Employment Growth











City of San Jose Economic Forecast

The City of San Jose Department of Planning, Building, and Code Enforcement prepared a construction forecast (Exhibit 21). It predicts an increase in development for San Jose over the 2019-2023 period:

"Construction valuation in fiscal year 2017/2018 is expected to exceed the previous five-year average, aided by a particularly strong year in new commercial and residential construction, and industrial alterations. Future development is predicted to be driven by mixed-use residential projects, and certain commercial and industrial sectors as described above. San José is poised to capitalize on on-going demand for office and warehouse space for expanding companies that has led to low vacancy rates and high rents in neighboring cities."

Exhibit 21: San Jose Construction Forecast

Residential Units and Non-Residential Square Footage: FY 12/13 to FY 22/23

	Actual					Projected					
Fiscal Year	**12/13**	**13/14**	**14/15**	**15/16**	**16/17**	**17/18**	**18/19**	**19/20**	**20/21**	**21/22**	**22/23**
Residential (Units)											
Single-Family	284	341	254	152	201	275	275	275	275	275	275
Multi-Family	2,418	4,383	2,987	1,540	2,511	2,900	2,600	2,450	2,450	2,450	2,450
Total	**2,702**	**4,724**	**3,241**	**1,692**	**2,712**	**3,175**	**2,875**	**2,725**	**2,725**	**2,725**	**2,725**
Non-Residential ('000s sqft)											
Commercial	500	1,400	2,000	1,854	1,911	3,500	2,000	1,800	1,400	1,400	1,400
Industrial	790	1,200	1,000	2,068	1,452	2,400	1,000	1,000	1,000	1,000	1,000
Total	**1,290**	**2,600**	**3,000**	**3,922**	**3,363**	**5,900**	**3,000**	**2,800**	**2,400**	**2,400**	**2,400**

Note: Data on residential units based on the Building Division's Permit Fee Activity Report

Data on non-residential square footage estimated based on construction valuation in the Building Division's Permit Fee Activity Report

Wells Fargo Western Economic Outlook

The Wells Fargo report provides an economic forecast for the United States, based on the performance of major economic indicators. With regard to the western states, the forecast says:

"While the outlook for the West remains bright, we expect growth to moderate relative to the rest of the country."

The forecast includes a specific section for California, noting that the continued outperformance of the State compared to the nation could be at risk due to the threats to global trade and the affordability of housing.

- *"The California economy continues to outperform the rest of the nation. Real GDP grew 3.5 percent on a year-to-year basis in Q1 and has now outpaced the country as a whole for nearly six years. While the tech sector remains the primary driver of growth, most other major industries are performing well.*

- *Employment growth has been more modest over the past year, with nonfarm payrolls rising 2.0 percent in July. Even that more moderate pace still slightly exceeds the nation, however, and the unemployment rate has fallen to a modern-era low of 4.2 percent. Every metro area in the state and nearly every major industry added jobs over the past year. Construction posted the largest year-over-year gains, reflecting a ramp-up in home construction and continued gains in commercial development.*

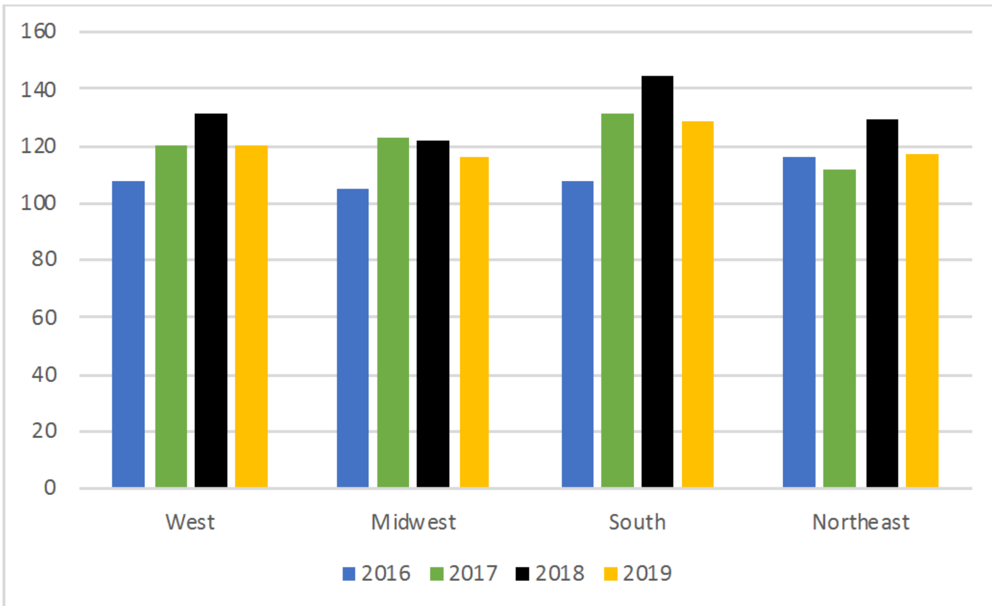
- *New housing supply should come as a welcome relief for Californians. Affordability remains a significant risk to the Golden State economy, as businesses are increasingly seeking more affordable options outside of the state. New supply has been slow to come back on track, which has helped drive home prices up much faster than income growth. The lack of affordable housing is causing younger workers to seek out alternative areas, such as Denver and Dallas.*

- *Trade disputes also pose a risk as California is home to some of the nation's busiest ports and is the second largest exporter behind Texas. NAFTA partners and China combined account for 34.9 percent of California's 2017 exports."*

Wells Fargo Construction Industry Forecast 2019

Wells Fargo uses an "Optimism Quotient" (Exhibit 22) to predict growth or contraction in the construction industry. Values over 100 are considered optimistic, and a positive sign for the construction industry. While the quotient for the west has declined from 131 (2018) to 120 (2019), Wells Fargo still considers the 2019 outlook positive.

Exhibit 22: Wells Fargo Optimism Quotient



Bank of the West California Economic Outlook

Bank of the West provides a report and forecast for California's economy, including jobs, housing, and trade. The executive summary notes:

- *"Job creation in California has outpaced that of the nation since March 2012. But California job growth peaked at 3.0% in 2015 and has been decelerating annually since then. This trend is expected to continue with growth forecast to slow from 1.8% this year to 1.2% in 2019 and just 0.5% in 2020 due to weaker global growth and tighter financial conditions.*

- *Among the four regions job growth in the Bay Area is expected to be the strongest this year at (2.0%) followed by the Central Valley (1.9%), the Central Coast (1.8%) and Southern California (1.4%).*

- *Job growth is expected to decelerate in all four regions of California in 2019 and 2020, while Bay Area is expected to become an under-performer in job creation as high costs of living and doing business weigh more heavily, net-migration turns negative and Silicon Valley faces new headwinds from trade protectionism and regulatory oversight.*

- *The California unemployment rate fell to an all-time low in April of this year and has remained there. As job growth slows in 2019 the unemployment rate is projected to rise from 4.2% in 2018 to 4.7% in 2020."*

- *"Net migration across all four regions and the state is projected to turn negative in 2019 and remain there in 2020 due to deterioration in the state's relative economic performance, the high cost of living, and congested freeways. This will weigh on housing demand, especially in Southern California.*

- *The Trump Administration's protectionist measures thus far have focused mainly on China, an important destination for California exports and driver of California port activity. This is an evolving downside risk to the California economy in 2019.*

- *An analysis by the Brookings Institution reveals that California employs 287,000 workers in those industries targeted by China's initial $50 billion in retaliatory tariffs.*

- *Brookings also determined that the counties in the state most impacted by the tariffs have higher-than-average unemployment rates. Therefore, the protectionist policies are more likely to result in increased economic insecurity for communities that are already struggling."*

The report also discusses how job growth has been strongest in construction, with a 4.7% increase in 2017-2018.

Exhibit 23 displays summary statistics for the Bay Area. In common with other forecasts, Bank of the West expects slower, but positive growth in many aspects. In particular, Bay Area job growth is held down by the low unemployment rate, meaning that fewer unemployed workers are available to fill new jobs.

Exhibit 23: Bank of the West California Bay Area Outlook

	2016	2017	2018	2019	2020
Labor Market					
Employment Growth	3.4%	2.3%	2.0%	1.1%	0.3%
Unemployment Rate	4.0%	3.4%	3.0%	3.2%	3.7%
Income and Spending Trends					
Personal Income Growth	5.0%	4.7%	4.7%	4.5%	4.0%
Median HH Income ($)	88,211	91,296	94,128	97,936	101,888
Retail Sales Growth	3.6%	5.5%	5.5%	4.7%	2.0%
Housing Market					
Total Housing Starts Growth	6.7%	13.1%	9.6%	-2.0%	-3.7%
Med. Existing 1-Unit Home Price	6.3%	12.3%	9.0%	5.6%	5.1%
Demographics					
Population Growth	0.8%	0.5%	0.5%	0.5%	0.4%
Net Migration (000's)	26.6	7.0	5.8	-4.0	-6.0

The Bay Area includes Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano and Sonoma counties

Long-term Forecasts

The limited number of long-term forecasts available tend to focus on population. Long-term population growth is a useful proxy for consumer demand, which in turn drives import flows of consumer goods, foods, and beverages, and industrial imports.

The forecasts (Exhibit 24) depict steady growth over the long term that falls short of the recent strength seen in California.

Exhibit 24: Long-Term Forecast Summaries

Forecast	Outlook
Federal Reserve Federal Open Market Committee Forecast, March 2019	National real GDP growth of about 1.9% annually over the long run, with a slight rise in the unemployment rate as the current tight labor market eases
Caltrans California County-Level Economic Forecast 2018-2050	County and statewide forecast of population, housing permits, income, and other factors.

ABAG Planning/Research Forecasts and Projections, 2016	Bay Area forecast of population and employment, with employment increasing by 1.0% annually between 2010 and 2035.
Plan Bay Area 2040, 2017	Bay Area forecast of population and employment, with employment increasing by 1.1% annually between 2010 and 2040.

Federal Reserve Federal Open Market Committee Forecast, March 2019

The most recent FOMC release (Exhibit 25) provides both annual forecasts through 2021 and a longer-term growth rate range. The long-run projections are the rates of growth, unemployment, and inflation to which the economy is expected to converge over time "in the absence of further shocks and under appropriate monetary policy." Overall, the FOMC expects long-run real GDP growth at about 1.9%, with a slight rise in the unemployment rate as the current tight labor market eases.

Exhibit 12: FOMC March 2019 Forecasts

Variable	Median[1]				Central tendency[2]				Range[3]			
	2019	2020	2021	Longer run	2019	2020	2021	Longer run	2019	2020	2021	Longer run
Change in real GDP	2.1	1.9	1.8	1.9	1.9 - 2.2	1.8 - 2.0	1.7 - 2.0	1.8 - 2.0	1.6 - 2.4	1.7 - 2.2	1.5 - 2.2	1.7 - 2.2
December projection	2.3	2.0	1.8	1.9	2.3 - 2.5	1.8 - 2.0	1.5 - 2.0	1.8 - 2.0	2.0 - 2.7	1.5 - 2.2	1.4 - 2.1	1.7 - 2.2
Unemployment rate	3.7	3.8	3.9	4.3	3.6 - 3.8	3.6 - 3.9	3.7 - 4.1	4.1 - 4.5	3.5 - 4.0	3.4 - 4.1	3.4 - 4.2	4.0 - 4.6
December projection	3.5	3.6	3.8	4.4	3.5 - 3.7	3.5 - 3.8	3.6 - 3.9	4.2 - 4.5	3.4 - 4.0	3.4 - 4.3	3.4 - 4.2	4.0 - 4.6
PCE inflation	1.8	2.0	2.0	2.0	1.8 - 1.9	2.0 - 2.1	2.0 - 2.1	2.0	1.6 - 2.1	1.9 - 2.2	2.0 - 2.2	2.0
December projection	1.9	2.1	2.1	2.0	1.8 - 2.1	2.0 - 2.1	2.0 - 2.1	2.0	1.8 - 2.2	2.0 - 2.2	2.0 - 2.3	2.0
Core PCE inflation[4]	2.0	2.0	2.0		1.9 - 2.0	2.0 - 2.1	2.0 - 2.1		1.8 - 2.2	1.8 - 2.2	1.9 - 2.2	
December projection	2.0	2.0	2.0		2.0 - 2.1	2.0 - 2.1	2.0 - 2.1		1.9 - 2.2	2.0 - 2.2	2.0 - 2.3	
Memo: Projected appropriate policy path												
Federal funds rate	2.4	2.6	2.6	2.8	2.4 - 2.6	2.4 - 2.9	2.4 - 2.9	2.5 - 3.0	2.4 - 2.9	2.4 - 3.4	2.4 - 3.6	2.5 - 3.5
December projection	2.9	3.1	3.1	2.8	2.6 - 3.1	2.9 - 3.4	2.6 - 3.1	2.5 - 3.0	2.4 - 3.1	2.4 - 3.6	2.4 - 3.6	2.5 - 3.5

Note: Projections of change in real gross domestic product (GDP) and projections for both measures of inflation are percent changes from the fourth quarter of the previous year to the fourth quarter of the year indicated. PCE inflation and core PCE inflation are the percentage rates of change in, respectively, the price index for personal consumption expenditures (PCE) and the price index for PCE excluding food and energy. Projections for the unemployment rate are for the average civilian unemployment rate in the fourth quarter of the year indicated. Each participant's projections are based on his or her assessment of appropriate monetary policy. Longer-run projections represent each participant's assessment of the rate to which each variable would be expected to converge under appropriate monetary policy and in the absence of further shocks to the economy. The projections for the federal funds rate are the value of the midpoint of the projected appropriate target range for the federal funds rate or the projected appropriate target level for the federal funds rate at the end of the specified calendar year or over the longer run. The December projections were made in conjunction with the meeting of the Federal Open Market Committee on December 18-19, 2018. One participant did not submit longer-run projections for the change in real GDP, the unemployment rate, or the federal funds rate in conjunction with the December 18-19, 2018, meeting, and one participant did not submit such projections in conjunction with the March 19-20, 2019, meeting.

1. For each period, the median is the middle projection when the projections are arranged from lowest to highest. When the number of projections is even, the median is the average of the two middle projections. Return to table

2. The central tendency excludes the three highest and three lowest projections for each variable in each year. Return to table

3. The range for a variable in a given year includes all participants' projections, from lowest to highest, for that variable in that year. Return to table

4. Longer-run projections for core PCE inflation are not collected. Return to table

Exhibit 26 provides greater detail on the GDP forecast.

- The "longer-run" real GDP growth forecast ranges from a high of 2.2% to a low of 1.7%.
- The "longer-run" expected range (“central tendency”) is from 1.8 to 2.0, with a median of 1.9%.

Exhibit 26 FOMC Change in Real GDP (Annual %), March 2019

	Actual					Forecast			
	2014	2015	2016	2017	2018	2019	2020	2021	Longer Run
Actual	2.7	2.0	1.9	2.5	3.1	-	-	-	-
Upper End of Range						2.4	2.2	2.2	2.2
Upper End of Central Tendency						2.2	2.0	2.0	2.0
Median						2.1	1.9	1.8	1.9
Lower End of Central Tendency						1.9	1.8	1.7	1.8
Lower End of Range						1.6	1.7	1.5	1.7

California County-Level Economic Forecast 2018-2050

This county-by-county forecast through 2050 uses data from the UCLA Anderson Forecast:

- “The UCLA Anderson Forecast makes projections of state and national economic indicators several times each year, and we have relied on these forecasts to influence the regional forecasts. UCLA Anderson’s June 2018 U.S. and California economic projections were used for the county forecasts presented in this report."
- "The County level forecasts are updated annually to incorporate (1) substantially revised historical data and (2) changes in the U.S. and California economic forecasts, which influence the direction of the regional economies. Consequently, in explaining the forecast, greater attention is directed at the near term, principally the next three years. However, a growth forecast for economic indicators is presented (for comparison purposes) for the 2018 to 2023 period for every county".
- "The longer term forecasts, from 2024 to 2050, are based on the extrapolation of near term forecast results. These long term “trend” forecasts respond to how the economic indicators might grow (or change) over time, consistent with reasonable assumptions about population and housing growth, and the growth of the U.S. and California economies. They are also created in a manner that is consistent with historical trends.”

For the near term, the California County Level Economic Forecast which extends through 2050 has a similar outlook as the UCLA Anderson Forecast, which influences the regional forecasts. At the State level:

- The forecast also projects a slowdown in construction job growth. After 2018 the rate of growth of new housing permits issued per year is forecast to slow, with an average of 131,000 per year between 2018 and 2022.
- California’s population growth is projected at about 0.7% for the next several years through 2022, with about 280,000 new residents projected per year.

The County Level forecast includes a near-term forecast specifically for Alameda County with the following highlights:

- *In 2018, total employment will increase by 1.7 percent. From 2018 to 2023, employment growth is expected to average 0.8 percent per year.*

- *The largest employment gains will be observed in professional services, education and healthcare, and leisure services. Together, these sectors will account for 67 percent of net job creation during the 2018-2023 period.*

- *We are near the peak of the current building cycle, and job losses may be observed in the construction industry during the forecast period.*

- *Average salaries are currently well above the California average, and will remain so over the foreseeable future. In Alameda County, inflation-adjusted salaries are expected to rise by an average of 1.4 percent per year between 2018 and 2023.*

- *Over the forecast period, an average of 6,300 homes will be authorized per year. The most prominent area for development will be the Oakland Waterfront, where several thousand apartments and condos could be built over the next decade.*

- *The population is expected to increase by 0.7 percent annually through 2023. Net migration will slow, with an average of 2,100 net migrants entering the county each year.*

Exhibit 27 was developed by the consultant team from the County Level forecast to summarize the outlook for the 19 major counties in the California market served by the Bay Area ports.

The 19 counties shown vary in character from large urban clusters to less populous agricultural areas. Combined, they have:

- A population of about 13 million, expected to grow at an annual average compound rate of 0.7%, adding 3 million people by 2048.
- A total of 37,071[i] new home permits in 2017, declining to 30,432 by 2048, but adding 1+ million homes over 30 years.
- About $16 trillion in real personal income in 2017, rising at 1.7% to $27 trillion in 2048.
- About $27 billion in annual farm crop value rising at 0.8% to $35 billion in 2048.
- Roughly $140 billion in annual industrial production, rising at 1.9% to reach $254 billion in 2048.

i This total was adjusted as indicated in **Exhibit 14** to avoid large year-to-year fluctuations.

Exhibit 14: 19-County Forecast

County	County	Metrics: Population	Metrics: New Homes Permitted*	Metrics: Real Per Capita Income	Metrics: Real Personal Income - Billions	Metrics: Real Farm Crop value - Billions	Metrics: Real Industrial Production - Billions	Compound Annual Growth Rates: Population CAGR	Compound Annual Growth Rates: Annual Homes CAGR	Compound Annual Growth Rates: Real Per Capital Income CAGR	Compound Annual Growth Rates: Real Personal Income CAGR	Compound Annual Growth Rates: Real Farm Crop Value CAGR	Compound Annual Growth Rates: Real Industrial Production CAGR
Alameda	2017	1,650,818	*5,500*	$ 69,350.00	$ 114.5	0.0	22.6						
	2048	1,990,314	3,971	$ 93,588.00	$ 186.3	0.0	46.5	0.6%	-1.0%	1.0%	1.6%	NA	2.4%
Contra Costa	2017	1,138,039	*2,800*	$ 74,731.00	$ 85.0	0.1	5.6						
	2048	1,419,039	3,156	$ 96,197.00	$ 136.5	0.1	10.3	0.7%	0.4%	0.8%	1.5%	0.0%	2.0%
Fresno	2017	999,929	3,050	$ 40,612.00	$ 40.6	6.3	8.5						
	2048	1,351,570	3,154	$ 52,109.00	$ 70.4	8.0	17.8	1.0%	0.1%	0.8%	1.8%	0.8%	2.4%
Madera	2017	157,472	438	$ 38,158.00	$ 6.0	1.9	1.0						
	2048	223,842	527	$ 48,563.00	$ 10.9	2.3	2.1	1.1%	0.6%	0.8%	1.9%	0.6%	2.4%
Marin	2017	262,545	104	$ 121,715.00	$ 32.0	0.1	1.4						
	2048	274,104	30	$ 174,442.00	$ 47.8	0.1	2.9	0.1%	-3.9%	1.2%	1.3%	0.0%	2.4%
Merced	2017	276,275	670	$ 37,034.00	$ 10.2	3.5	2.9						
	2048	369,356	788	$ 47,040.00	$ 17.4	4.6	5.8	0.9%	0.5%	0.8%	1.7%	0.9%	2.3%
Monterey	2017	442,808	648	$ 53,901.00	$ 23.9	4.6	2.1						
	2048	504,643	561	$ 73,267.00	$ 37.0	5.6	4.4	0.4%	-0.5%	1.0%	1.4%	0.6%	2.4%
Napa	2017	141,624	183	$ 70,186.00	$ 9.9	0.7	3.5						
	2048	160,635	207	$ 104,150.00	$ 16.7	1.1	8.0	0.4%	0.4%	1.3%	1.7%	1.5%	2.7%
Sacramento	2017	1,519,381	4,915	$ 50,052.00	$ 76.0	0.5	7.2						
	2048	1,923,180	4,196	$ 71,556.00	$ 137.6	0.6	13.6	0.8%	-0.5%	1.2%	1.9%	0.6%	2.1%
San Benito	2017	58,416	599	$ 48,960.00	$ 2.9	0.4	0.6						
	2048	83,311	175	$ 56,629.00	$ 4.7	0.4	1.2	1.2%	-3.9%	0.5%	1.6%	0.0%	2.3%
San Francisco	2017	880,418	4,736	$ 114,181.00	$ 100.5	0.0	5.9						
	2048	1,040,960	2,712	$ 180,251.00	$ 187.6	0.0	11.4	0.5%	-1.8%	1.5%	2.0%	NA	2.1%
San Joaquin	2017	749,092	2,545	$ 41,522.00	$ 31.1	2.5	9.0						
	2048	983,053	2,026	$ 54,038.00	$ 53.1	3.1	19.0	0.9%	-0.7%	0.9%	1.7%	0.7%	2.4%
San Mateo	2017	772,900	1,759	$ 110,949.00	$ 85.8	0.1	11.8						
	2048	935,164	1,613	$ 152,099.00	$ 142.2	0.0	24.5	0.6%	-0.3%	1.0%	1.6%	-100.0%	2.4%
Santa Clara	2017	1,945,465	*5,500*	$ 92,544.00	$ 180.0	0.3	37.3						
	2048	2,297,042	3,563	$ 140,361.00	$ 322.4	0.4	44.8	0.5%	-1.4%	1.4%	1.9%	0.9%	0.6%
Santa Cruz	2017	276,801	322	$ 61,809.00	$ 17.1	0.7	1.9						
	2048	307,601	218	$ 78,632.00	$ 24.2	0.8	3.6	0.3%	-1.3%	0.8%	1.1%	0.4%	2.1%
Solano	2017	437,309	995	$ 48,368.00	$ 21.2	0.4	3.8						
	2048	528,189	967	$ 61,237.00	$ 32.3	0.4	7.8	0.6%	-0.1%	0.8%	1.4%	0.0%	2.3%
Sonoma	2017	504,671	876	$ 59,023.00	$ 29.8	0.8	6.3						
	2048	550,296	569	$ 87,021.00	$ 47.9	1.1	12.8	0.3%	-1.4%	1.3%	1.5%	1.0%	2.3%
Stanislaus	2017	551,557	939	$ 42,190.00	$ 23.3	3.2	6.5						
	2048	735,806	1,410	$ 56,256.00	$ 41.4	5.3	12.3	0.9%	1.3%	0.9%	1.9%	1.6%	2.1%
Yolo	2017	219,468	492	$ 50,681.00	$ 11.1	0.7	2.6						
	2048	284,318	589	$ 70,694.00	$ 20.1	0.8	5.2	0.8%	0.6%	1.1%	1.9%	0.4%	2.3%
19-County	**2017**	**12,984,988**	**37,071**	**1,225,966**	**$ 15,919.2**	**26.8**	**140.5**						
Market Area	**2048**	**15,962,423**	**30,432**	**1,698,130**	**$ 27,106.3**	**34.7**	**254.0**	**0.7%**	**-0.6%**	**1.1%**	**1.7%**	**0.8%**	**1.9%**

* Housing permits in italics normalized to avoid atypical values

ABAG Planning/Research Forecasts and Projections, 2016

The Association of Bay Area Governments (ABAG) has prepared a 2035 Bay Area forecast for population and employment by industry. These forecasts are part of Plan Bay Area 2040 discussed below.

The forecast (Exhibit 28) predicts that population will increase from 7,150,739 in 2010 to 8,889,000 in 2035. It also predicts that employment will grow from 3,268,680 to 4,198,400 in the same period (1.0% CAGR). The forecast also includes figures for the construction industry, which is expected to grow from 142,350 to 217,080 employees during this time (1.5% CAGR).

Exhibit 28: ABAG Population and Employment Projections

Bay Area Regional Projections

Demographics	2010	2015	2020	2025	2030	2035	2040
Population	7,150,739	7,461,400	7,786,800	8,134,000	8,496,800	8,889,000	9,299,100
Household Population	7,003,059	7,307,400	7,623,700	7,961,900	8,313,900	8,690,400	9,084,800
Households	2,608,023	2,720,410	2,837,680	2,952,910	3,072,920	3,188,330	3,308,090
Persons Per Household	2.69	2.69	2.69	2.70	2.71	2.73	2.75
Employed Residents	3,268,680	3,547,310	3,849,790	3,949,620	4,052,020	4,198,400	4,350,070

Jobs	2010	2015	2020	2025	2030	2035	2040
Agriculture & Natural Resources	24,640	25,180	25,690	24,800	23,940	23,330	22,750
Construction	142,350	168,380	197,560	203,280	209,150	217,080	225,290
Manufacturing & Wholesale	460,170	473,360	486,720	476,580	467,010	461,330	456,080
Retail	335,930	352,550	370,260	372,210	374,060	379,210	384,420
Transportation & Utilities	98,710	108,320	119,080	120,650	122,090	124,760	127,360
Information	121,070	134,550	149,640	150,890	152,130	154,720	157,330
Financial & Leasing	186,070	204,730	225,520	226,770	227,680	230,880	233,790

Plan Bay Area 2040, 2017

Plan Bay Area was developed by MTC and ABAG in cooperation as a general forecast of economics and population for the nine-county San Francisco Bay Area region through 2040:

"The forecast for Plan Bay Area is a cooperative effort between the ABAG research program, the Metropolitan Transportation Commission (MTC) modeling team, and local jurisdiction planning staff. ABAG develops regional totals for population, households, employment, output, and income. Geographic distribution of the forecast within the region is accomplished through efforts of ABAG and MTC modeling and planning staff with input at several stages from local jurisdictions. MTC then uses the information from the geographic distribution of the forecast for detailed travel demand analysis and estimates of greenhouse gas production."

Plan Bay Area forecasts that between 2010 and 2040, Bay Area employment will grow from 3.4 to 4.7 million jobs, while the population is projected to grow from 7.2 to 9.6 million people. This population will live in almost 3.4 million households, an increase of nearly 800,000 households over 2010 levels. Specifically, Plan Bay Area estimates (Exhibit 29):

- An increase of 1.3 million jobs between 2010 and 2040. Almost half of those jobs—over 600,000—were already added between 2010 and 2015.

- An increase of 2.4 million people between 2010 and 2040. Almost one fourth of the projected growth already occurred between 2010 and 2015.

Exhibit 29: Plan Bay Area Forecasts

	2010	2040
Employment	3.4 million	4.7 million
Population	7.2 million	9.6 million
Households	2.6 million	3.4 million

The employment and population projections are slightly more aggressive than the earlier ABAG forecasts.

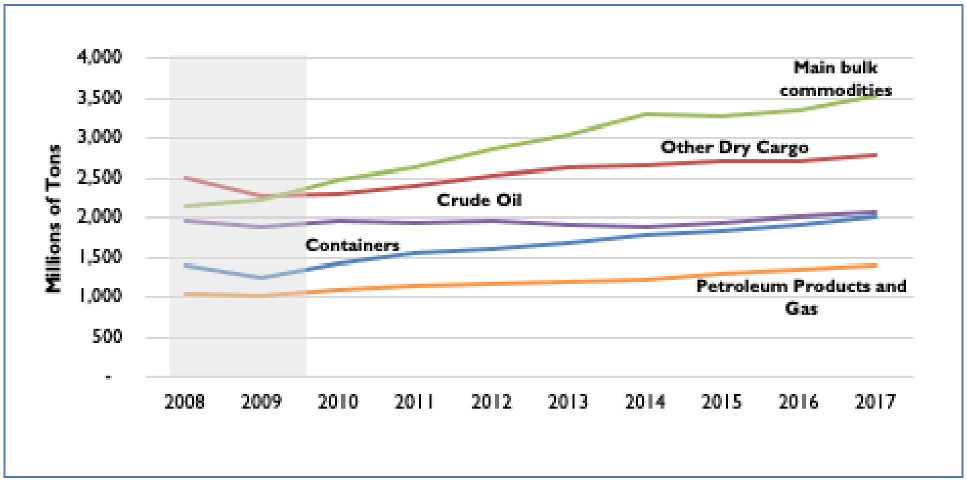
Trade Trends

Global Maritime Trade

As Exhibit 30 shows, global maritime trades began to grow again after the recession. Different commodity groups had different growth patterns.

- Container cargo grew moderately but steadily.
- Other dry cargo, which includes commodities such as cement aggregates, and gypsum handled at Bay Area ports, also grew moderately.
- Main bulk commodities, of which only coal moves through Bay Area ports, have grown more dramatically.
- Liquid bulk crude oil, petroleum products, and gas grew more slowly, although the growth of U.S. fracking and oil production has resulted in increased exports of crude oil and liquefied natural gas in recent years. Some of these commodities are handled at private refinery terminals and are outside the scope of the Seaport Plan.

Exhibit 30: Global Maritime Trade in Tons



NOTES: Main bulk commodities include iron ore, coal, and grain. Other dry cargo includes bauxite/alumina, phosphate, forestry and steel products, cement, etc. Shaded gray box indicates period of global recession, which the National Bureau of Economic Research details as starting in December 2007 and ending in June 2009 in the United States.

SOURCE: United Nations Conference on Trade and Development (UNCTAD), Review of Maritime Transport: 2018, available at http://unctadstat.unctad.org/ as of October 2018.

The outlook for world merchandise trade in the short term is for a lower rate of growth than in recent years. The World Trade Organization projects growth of 2.6% in 2019 and 3.0% in 2020, compared to growth of 4.6% in 2017 and 3.0% in 2018.

The report sections below discuss current trends in containerized, dry bulk, ro-ro, and bulk shipping.

IMO 2020. One change that will affect all types of shipping is the "IMO 2020" requirement for use of low-sulfur fuel. Starting in January 2020, the IMO will cap the sulfur content of marine diesel fuel used in international trade at 0.5%, down from the current 3.5%. Vessels operating in the Emissions Control Areas (ECAs) along the U.S. coasts are already required to use low sulfur fuel (0.1%). Vessel operators can comply with IMO 2020 in three ways:

- Using ultra-low sulfur fuel oil (ULSFO).
- Installing vessel exhaust scrubbers to reduce sulfur emissions from existing diesel fuels.`
- Converting to LNG as a fuel supply in addition to or instead of diesel fuel.

All of these options are costly and it is not obvious how or if the shipping industry will meet the IMO 2020 requirement. Among other factors, there is an insufficient supply of ULSFO, and refineries require costly and lengthy modifications to increase production.

The cost of meeting IMO 2020 requirements will increase shipping costs by some amount as yet unknown, although several shipping alliances have developed surcharge formulas based on potential bunker fuel prices. The impact on relatively high-value cargo such as containerized consumer imports or high-value exports, or ro-ro automobiles, is likely to be minor as shipping costs for those goods are a small part of total delivered price. IMO 2020 costs are more likely to affect flows of low-value containerized and bulk commodities where shipping costs account for a larger share of delivered price and are more likely to affect demand. Examples of affected commodities could include bulk export scrap metal or containerized export waste paper. Some imports, such as gypsum to Redwood City, are already arriving in "clean" vessels and will be minimally affected.

Trade Wars and Tariffs. The trade initiatives launched by the current U.S. administration, the enacted and proposed tariffs on imports to the U.S., and the tariffs on U.S. exports enacted and proposed by foreign governments in response, will all have mixed impacts on Bay Area trade.

- Threats of tariffs on imports, particularly imports from China, have led to an import surge due to “frontloading,” as explained in more detail below.
- Tariffs and uncertainty have reduced some recent U.S. exports. Those most affected, however, such as soybeans, are not major Bay Area commodities.
- For the near term, volatile and unpredictable trade conditions will likely constrain overall trade growth, but with impacts varying by commodity and trading partner.
- In the long run, tariffs and non-tariff barriers will slow the growth of trade.

The administration’s focus on trade with China is also leading manufacturers and importers to shift production and sourcing to other countries, notably Vietnam. This trend can have two impacts:

- Increased vessel service between Vietnam and other Asian nations and the U.S. West Coast. For example, a new service between Vietnam and Oakland began in early 2019.
- For inland U.S. destinations, a shift between transpacific intermodal routes through the West Coast and Suez Canal all-water or intermodal routes via the East Coast (potentially counter-balanced by higher shipping costs due to IMO 2020).

The second trend is more likely to affect Southern California ports, which depend far more on intermodal connections than Oakland.

IV. Containerized Cargo

Containerized Cargo Forecast Review

Cargo that is not moved in bulk or roll-on/roll-off vehicle service now typically moves in international containers. International containers are most often 40' long, but also come in 20' and 45' lengths (53' containers are used within the U.S., and do not ordinary travel on oceangoing vessels). Container volumes and capacities ate usually measured in "twenty-foot equivalent units" (TEU). A 20' container is one TEU, and a 40' container would be two TEU. There is usually a ratio of about 1.8 TEU per container to account for the mix of 20', 40', and 45' units.

The previous containerized cargo forecasts prepared for BCDC were developed by Tioga in 2009 to assist BCDC in evaluating the proposed use of Richmond's Port Potrero site for ro-ro cargo rather than for containers. The forecast is shown in Exhibit 31 below. That forecast was prepared toward the end of the 2008-2009 recession, and reflected widespread expectations for a relatively strong recovery. As the comparison in Exhibit 31 suggests, post-recovery trade growth deviated from those expectations.

Exhibit 31: 2009 Port of Oakland Containerized Cargo Forecast Comparison

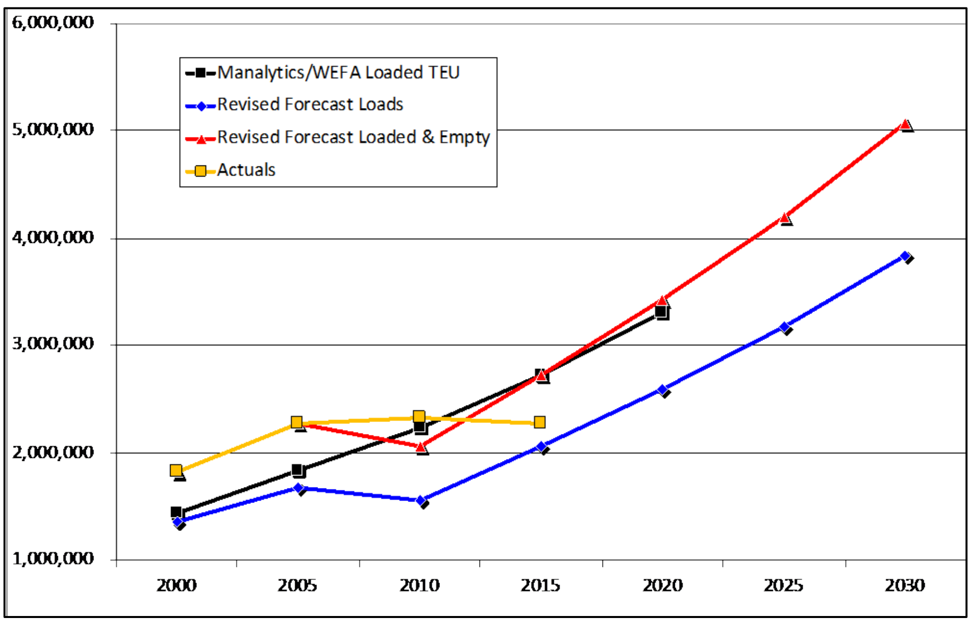


Exhibit 32 displays 1998–2018 annual Port of Oakland TEU counts and the 2009 forecast shown in Exhibit 31.

Exhibit 32: Port of Oakland Annual Total TEU, 1998-2018

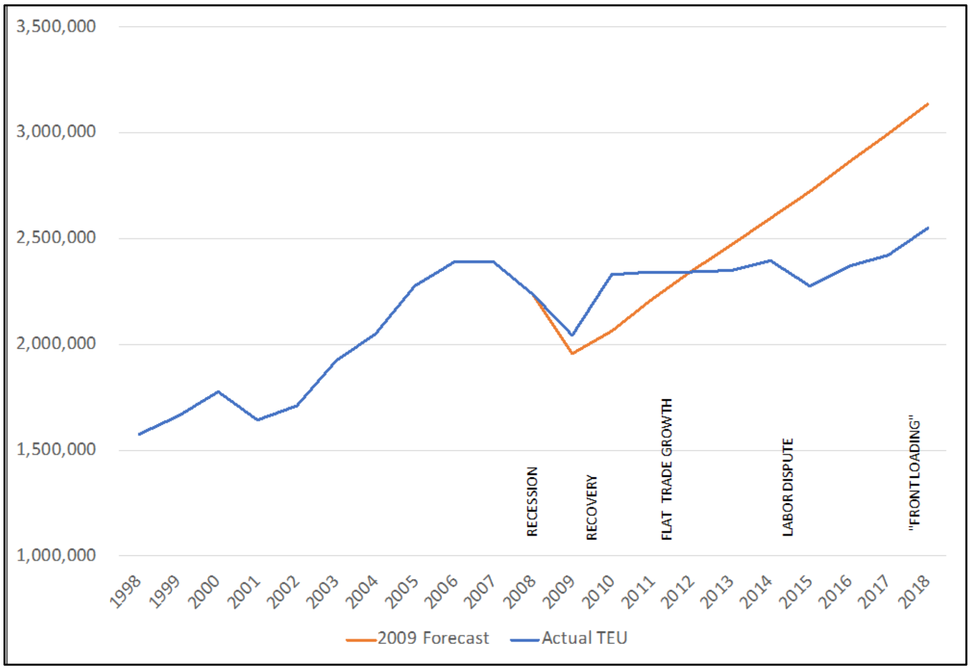
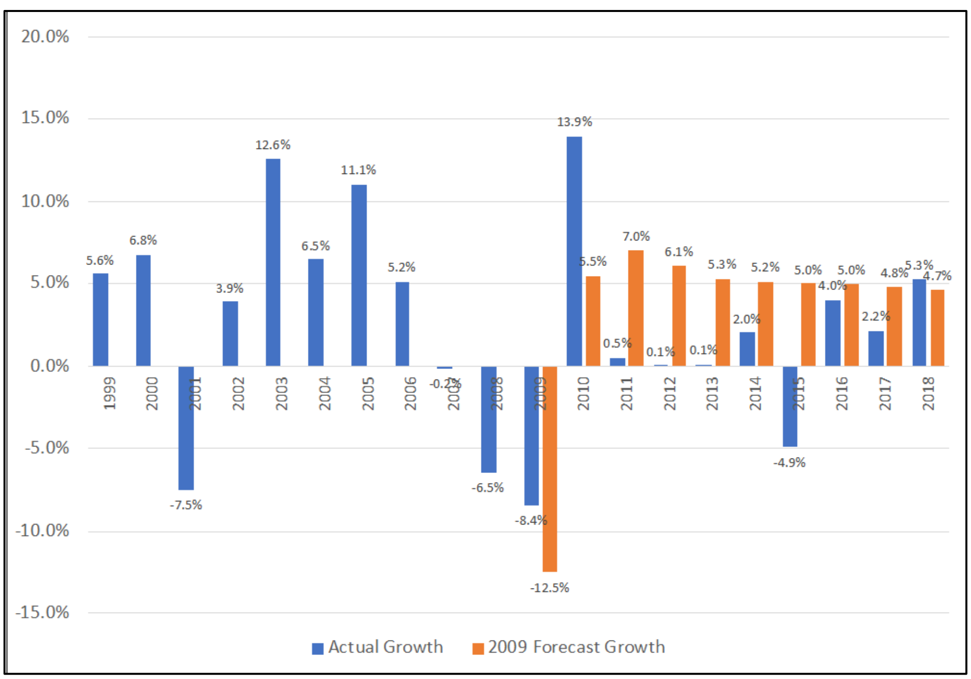


Exhibit 33 shows the corresponding growth rates.

Exhibit 33: Port of Oakland Annual Total TEU Growth Rates, 1999-2018



- The 2009 forecast was developed during the 2007–2009 recession, and anticipated a more severe 2008–2009 decline (-12.5%) than actually occurred (-8.4%).

- The 2009 forecast called for relatively steady growth at 4.7–5.3% after a moderate recovery in 2010–2012.

- Actual 2010 recovery was stronger (13.9%), but then the recovery “stalled” and Oakland’s TEU volume was nearly flat in 2011–2013. The forecast was almost exactly equal to the actual in 2012.

- After a moderate increase at the start of 2014, the PMA-ILWU contract dispute that began in November 2014 lead to a net volume loss in 2015.

- Recovery in 2016 and moderate growth in 2017 put the Port of Oakland “back on track,” but from a lower starting point.

- In 2018, import inventory buildup in advance of proposed tariffs (termed import “front loading”) contributed to stronger growth than forecast.

Overall, the 2009 forecast called for 3,136,317 TEU in 2018, while Oakland was actually at 2,548,837. Exhibit 34 below breaks the 1998–2018 period into three segments:

- 1998–2008, in which Oakland TEU grew at a CAGR of 3.6%.

- 2008–2015, in which the forecast anticipated an overall CAGR of 2.9% but flat post-recession trade, and the 2014–2015 dispute held the actual CAGR to 0.3%.

- 2015–2018, in which 3.8% growth approximated the pre-recession average, but was still lower than the forecast CAGR of 4.8%.

Exhibit 34: Port of Oakland Total TEU CAGRs by Era

Actual TEU and Forecast	1998-2008 CAGR	2008-2015 CAGR	2015-2018 CAGR	1998-2018 CAGR
Actual TEU	3.6%	0.3%	3.8%	2.4%
2009 Forecast	3.6%	2.9%	4.8%	3.5%

The near lack of any net growth in 2008–2015 thus held down the overall 1998–2018 CAGR to 2.4% versus the 3.5% forecast in 2009. However, as noted below, some of the slower-than-expected growth in recent years is attributable to a decline in domestic container trade.

Oakland Import TEU

Oakland’s import record (Exhibit 35 and Exhibit 36) is less volatile than export or overall TEU. After flat post-recession growth and a loss of momentum in the 2014–2015 trade dispute, imports have grown much more in line with the 2009 forecast.

Exhibit 35: Port of Oakland Annual Loaded Import TEU, 1998-2018

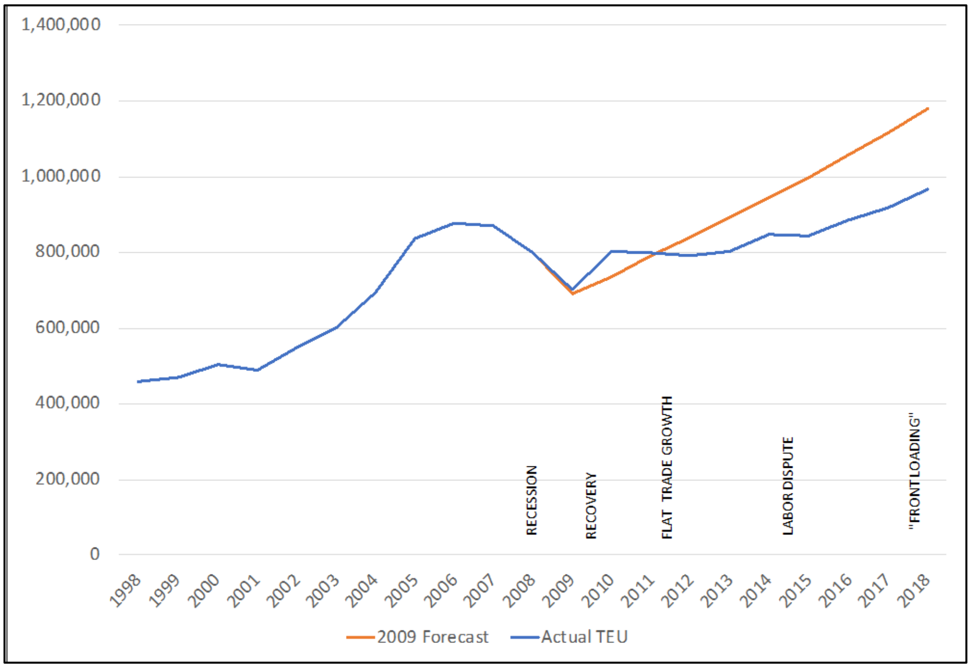
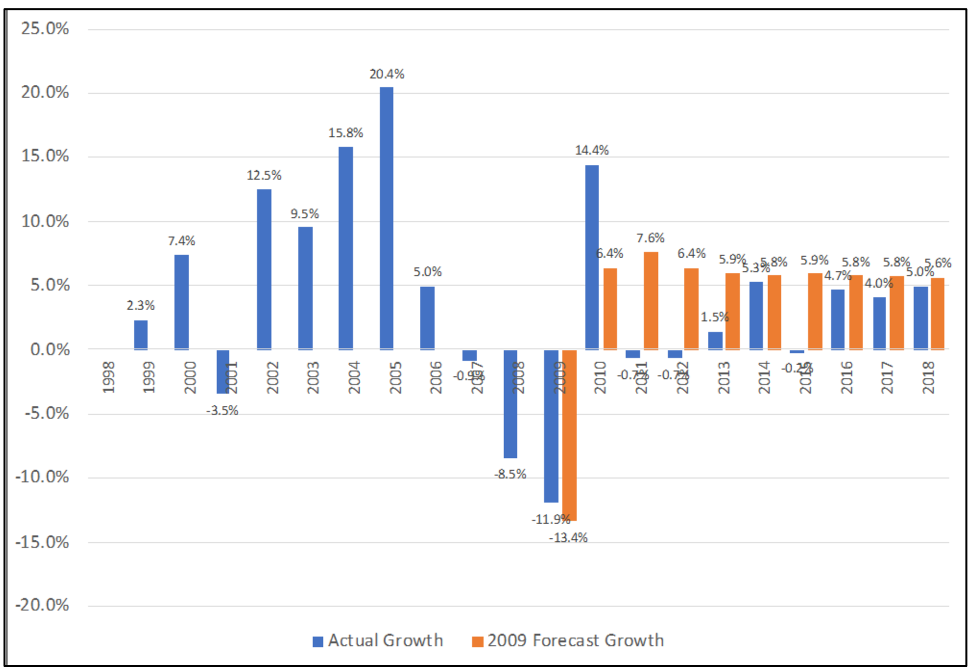


Exhibit 36: Port of Oakland Annual Loaded Import TEU Growth Rates, 1999-2018



As Exhibit 37 shows, import actuals lagged forecasts by about one percentage point in 2015–2018 and in 1998–2018 overall.

Exhibit 37: Port of Oakland Loaded Import TEU CAGRs by Era

Actual TEU and Forecast	1998-2008 CAGR	2008-2015 CAGR	2015-2018 CAGR	1998-2018 CAGR
Import TEU				
Actual Growth	5.7%	0.8%	4.6%	3.8%
2009 Forecast Growth	5.7%	3.3%	5.7%	4.8%

Oakland Export TEU

Exhibit 38 shows that Oakland's export TEU were affected much less by the recession and grew modestly post-recession, but have been on a downward trend since 2013. Exhibit 39 shows the volatility of Oakland's export growth. The CAGRs in Exhibit 40 show that the 2009 forecast was 2.5 to 3.1 percentage points above actuals.

Exhibit 38: Port of Oakland Annual Loaded Export TEU, 1998-2018

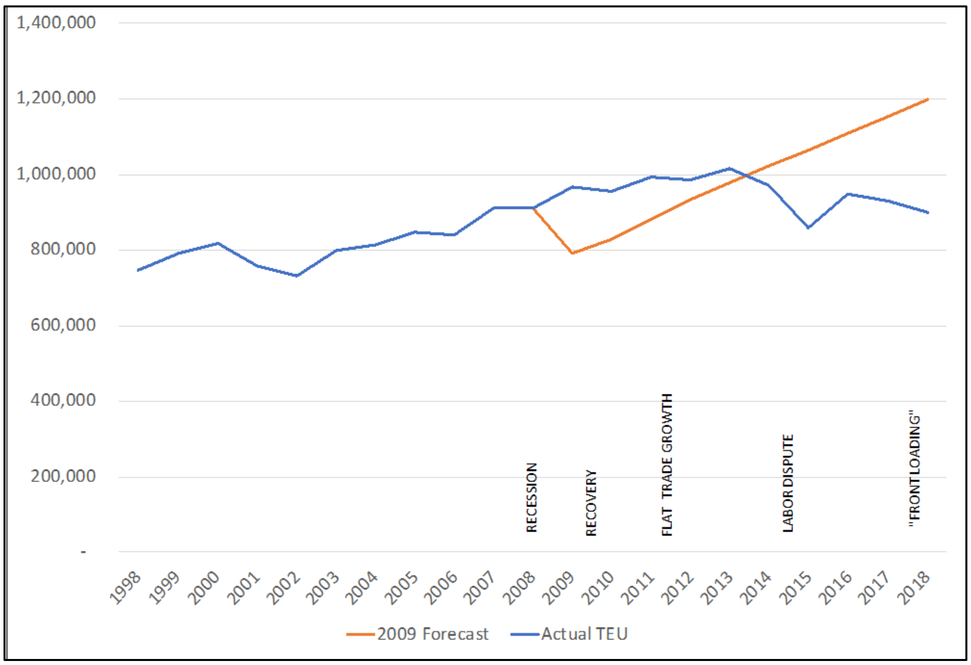
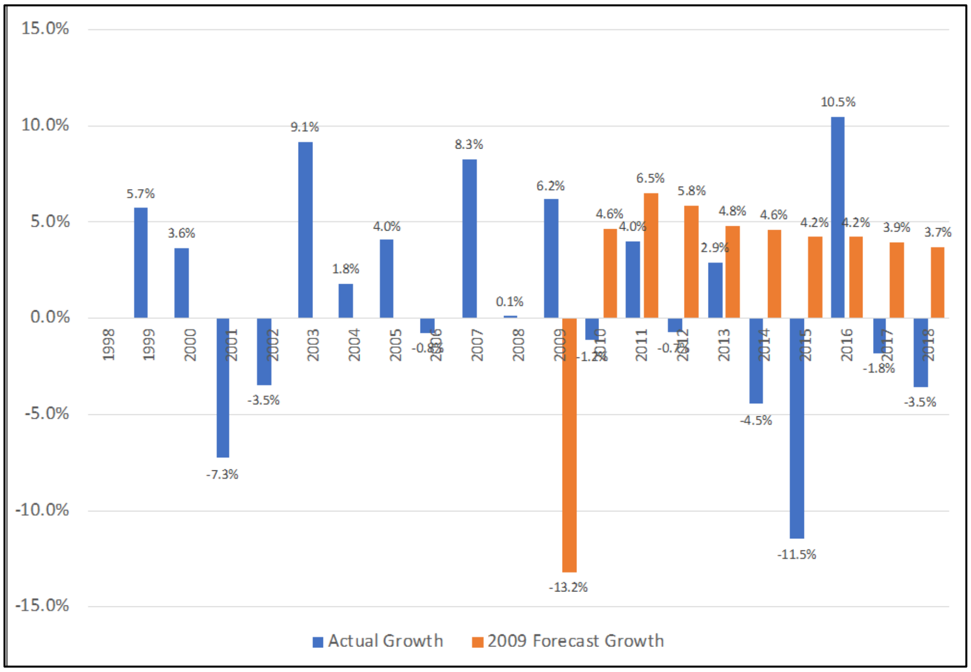


Exhibit 39: Port of Oakland Annual Loaded Export TEU Growth Rates, 1999-2018



In Exhibit 40, the substantial disparity between export forecast and export actuals is apparent. The 2014–2015 labor dispute brought export TEU down below the 2008 level after a high point in 2013. Growth since 2015 has been positive, but slow.

Exhibit 40 Port of Oakland Loaded Export TEU CAGRs by Era

Actual TEU and Forecast	1998-2008 CAGR	2008-2015 CAGR	2015-2018 CAGR	1998-2018 CAGR
Export TEU				
Actual Growth	2.0%	-0.8%	1.5%	0.9%
2009 Forecast Growth	2.0%	2.3%	4.0%	2.4%

Oakland Empty TEU

The Port of Oakland is unusual on the West Coast as having substantial volumes of both inbound and outbound empty containers.

- As with most West Coast ports, Oakland terminals load outbound empties to offset the overall U.S. excess of import over export containers.
- Oakland terminals also discharge a significant volume of empties, notably refrigerated containers, to fill the needs of exporters in California and other Western states.

As Exhibit 41 shows, empty movements dropped sharply during the recession as ocean carriers saw no purpose in returning empties to Asia if there were no U.S.-bound loads to fill them. Empty movements rose sharply in 2010 as the recovery pulled those empty containers back into circulation. There was little net increase in empty TEU volume between 2010 and 2017 (as also shown in Exhibit 42), but a strong uptick in 2018 likely driven by import "front loading" and subsequent generation of empties to be repositioned westbound.

Exhibit 41: Port of Oakland Annual Empty TEU, 1998-2018

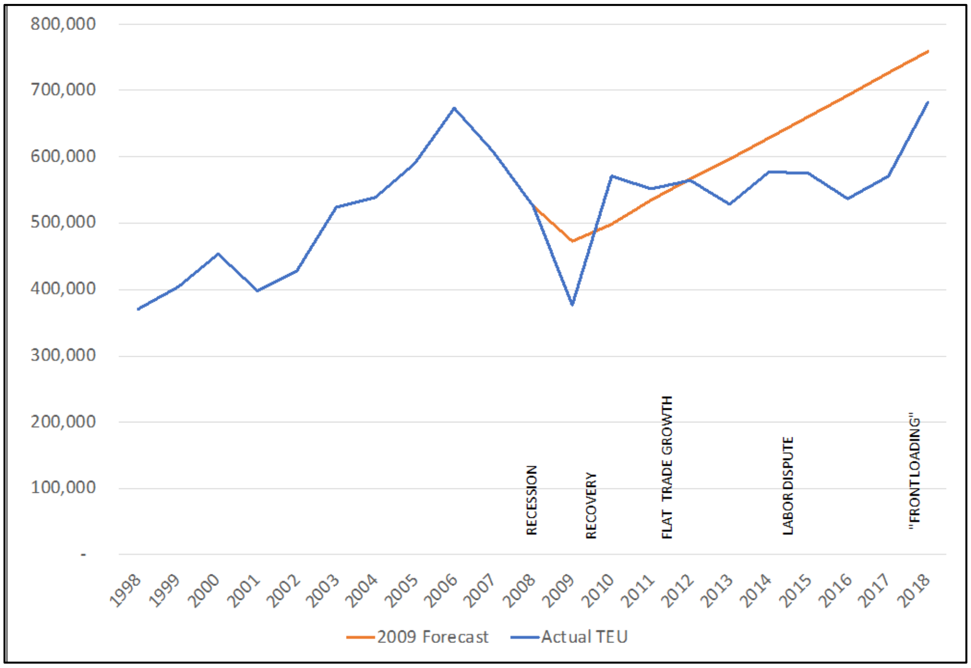
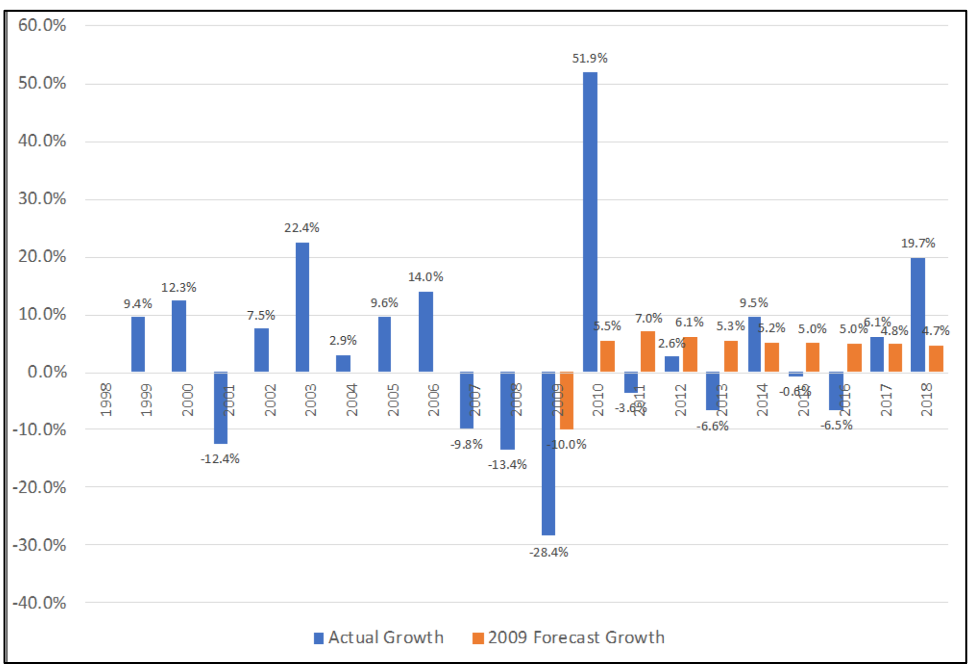


Exhibit 42: Port of Oakland Annual Empty TEU Growth Rates, 1999-2018



As Exhibit 43 indicates, Oakland's empty TEU volumes ran both ahead and behind forecast, depending on the era.

Exhibit 43 Port of Oakland Empty TEU CAGRs by Era

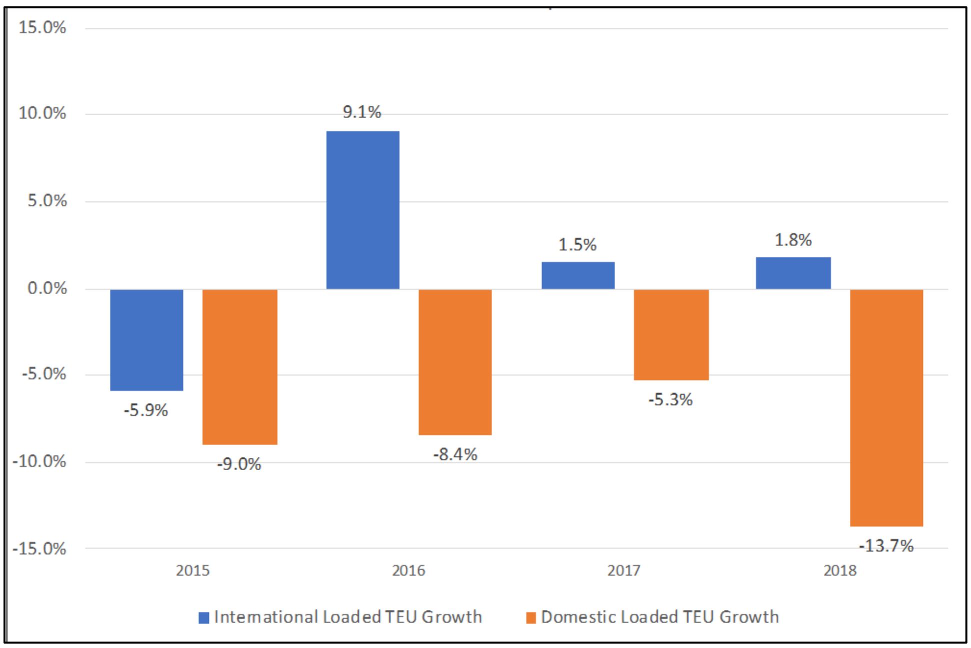
Actual TEU and Forecast	1998-2008 CAGR	2008-2015 CAGR	2015-2018 CAGR	1998-2018 CAGR
Empty TEU				
Actual Growth	3.6%	1.3%	5.9%	3.1%
2009 Forecast Growth	3.6%	3.3%	4.8%	3.7%

The relationship between empty and loaded container movements is complex, and will require additional analysis.

International vs. Domestic TEU

Discussions with the Port of Oakland have determined that domestic TEU (e.g. the Hawaiian and Guam trades) have declined noticeably in recent years, as shown in Exhibit 44. The domestic drop-off has therefore concealed some of the underlying international growth.

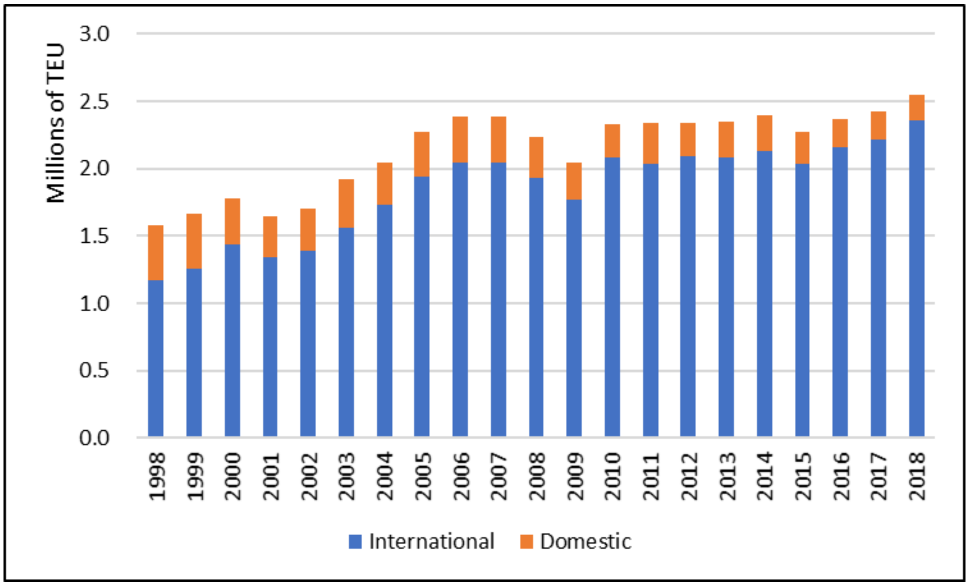
Exhibit 44: Port of Oakland International vs. Domestic Loaded TEU Growth, 2015-2018



Current Container Cargo Flows

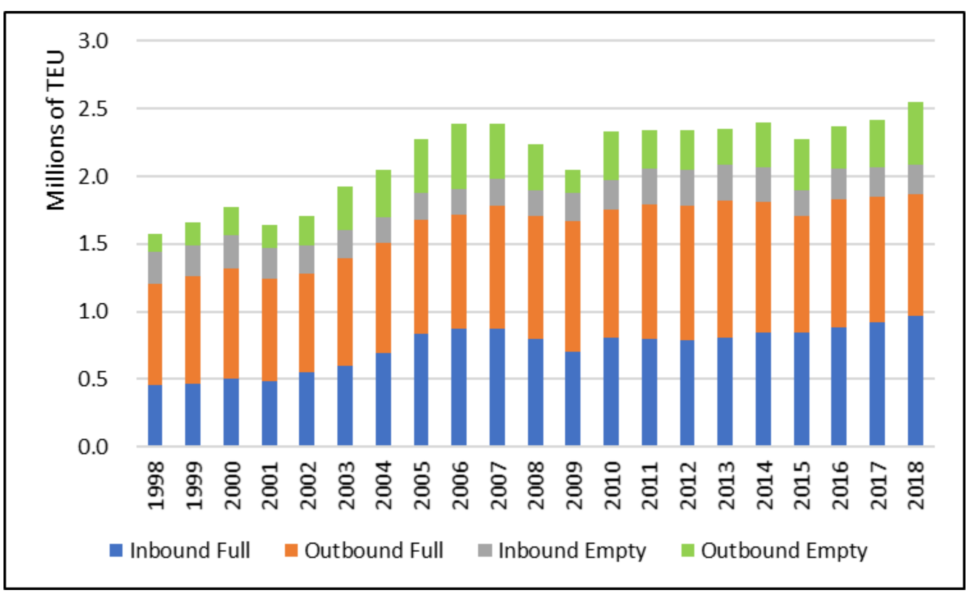
The Port of Oakland moved a total of 2.55 million TEU in 2018, comprised of 2.36 million international TEU and 189,443 domestic TEU. The share of the total containers handled at the Port of Oakland that are international has increased in three of the past 20 years, growing from 75.7% in 1999 to 92.6% in 2018 (Exhibit 45). The total number of TEU handled has increased at an annual rate of 1.1% since 2010, with international TEU increasing at an annual rate of 1.6% compared to an annual 3.4% decrease in domestic TEU.

Exhibit 45: Port of Oakland Container Trade by Type, 1998-2018



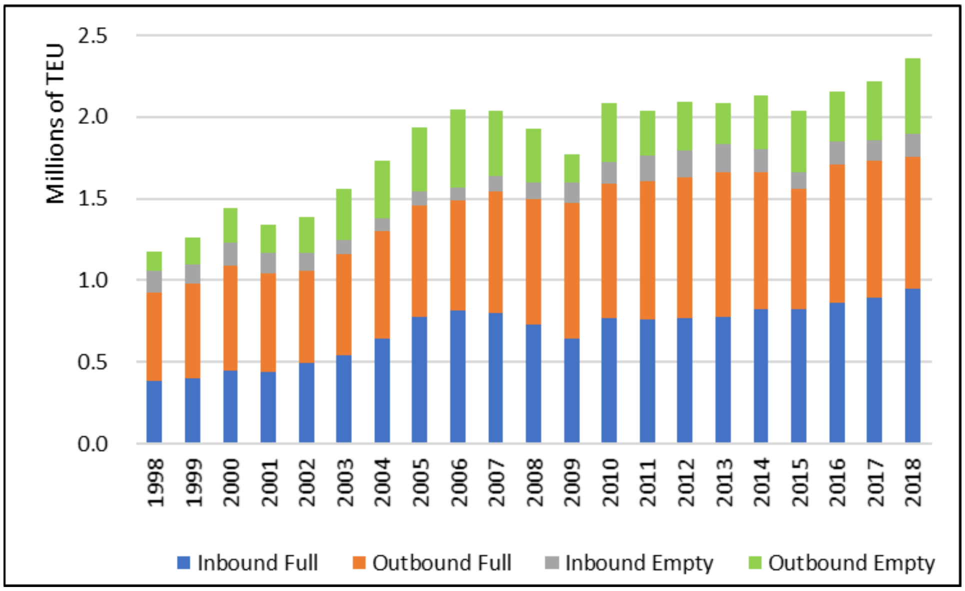
The mix of loaded and empty containers handled by the port varies by the direction of trade. The Port of Oakland handled 1.86 million loaded TEU in 2018 and 682,995 empty TEU, which equates to a 73% to 27% split (Exhibit 46). Loaded containers were almost evenly split between inbound and outbound moves, with 52% of loaded containers inbound compared to 48% that were outbound. The same was not true with empty containers, with just 32% of the total inbound compared to 68% that were outbound. Inbound loaded TEU have increased at an annual rate of 2.3% since 2010, while outbound loaded TEU have decreased at an annual rate of 0.8%. In contrast, inbound empty TEU have increased at an annual rate of 0.5% since 2010, while outbound empty TEU have increased at an annual rate of 3.1%.

Exhibit 46: Port of Oakland Total Container Trade by Direction, 1998-2018



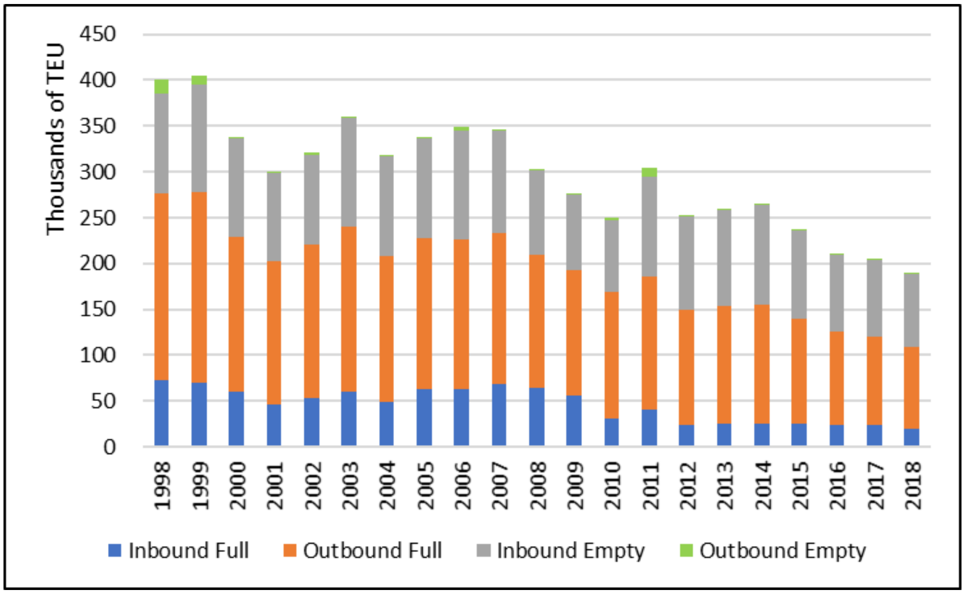
The Port of Oakland handled 1.75 million loaded international TEU in 2018 and 602,409 empty international TEU, which equates to a 74% to 26% split, with 54% of loaded containers inbound compared to 46% that were outbound (Exhibit 47). Empty containers were again dominated by the outbound direction of trade, with just 23% of the international inbound share compared to 77% that were outbound. Inbound loaded TEU have increased at an annual rate of 2.6% since 2010, while outbound loaded TEU have decreased at an annual rate of 0.2%. In contrast, inbound empty TEU have increased at an annual rate of 0.7% since 2010, while outbound empty TEU have increased at an annual rate of 3.2%.

Exhibit 47: Port of Oakland International Container Trade by Direction, 1998-2018



Total domestic volumes at the Port of Oakland have decreased in 12 of the last 20 years. The Port handled 108,857 loaded domestic TEU in 2018 and 80,586 empty domestic TEU, which equates to a 57% to 43% split (Exhibit 48). The direction of trade had a major impact on the percentage of containers that are loaded. For domestic loaded containers, 17% of TEU were inbound compared to 83% that were outbound, while for empty containers 98% of TEU were inbound compared to just 2% that were outbound. Inbound loaded TEU have decreased at an annual rate of 6.0% since 2010, while outbound loaded TEU have decreased at an annual rate of 5.2%. In contrast, inbound empty TEU have increased at an annual rate of 0.2% since 2010, although outbound empty TEU have decreased at an annual rate of 6.9%.

Exhibit 48: Port of Oakland Domestic Container Trade by Direction, 1998-2018



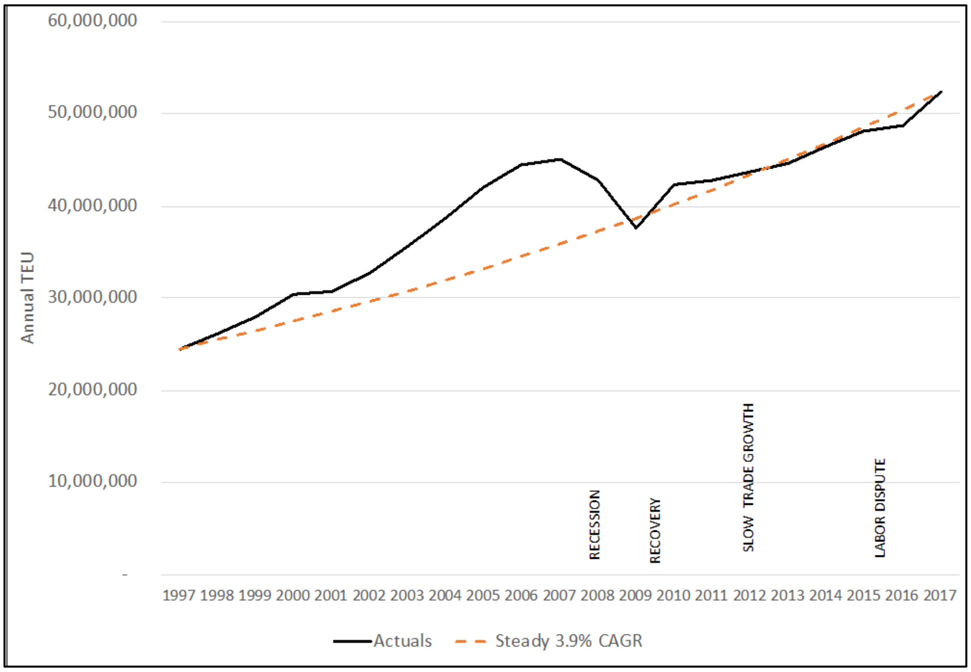
Containerized Shipping Trends

Overall U.S. Container Trade Growth

Overall U.S. container trade grew at an average compound annual growth rate (CAGR) of 3.9% since 1997. As Exhibit 49 shows, that growth has been uneven.

- After the brief "dot com" recession in 2001 U.S. container trade grew rapidly, reaching a new peak in 2007.
- The 2008–2009 recession led to a drastic drop in container trade.
- Post-recession recovery in 2010 was initially dramatic, but contrary to widespread expectations growth thereafter was much slower than before the recession. The 2007 peak was not regained until 2014.
- In late 2014 and early 2015, a prolonged dispute between management and labor at West Coast ports slowed trade growth.
- Recent industry forecasts anticipate that near-term growth will be slower than the long-term average.

Exhibit 49: U.S. Containerized Trade Growth, 1997-2018



"Frontloading" Imports

Late 2018 saw a strong influx of Asian imports due to import "frontloading" – increasing inventory in advance of announced or potential tariff actions. This short-term trend affected Southern California ports more than Oakland, although TEU imports to Oakland posted year-on-year growth of 15% and 11% respectively.

"Frontloading" has apparently abated in 2019. The tariff situation remains volatile, even unpredictable as of spring 2019. "Frontloading" is intrinsically a short-term trend, limited by the ability of the U.S. distribution system to absorb inventory and inventory cost.

Within the forecast context, frontloading can best be viewed as a shift of trade from later to earlier dates. This view assumes that the inventory amassed in late 2018 is a substitute for imports that would otherwise have arrived in 2019. Thus, while trade policy shifts will affect long-term cargo trends, the practice of frontloading should not.

Frontloading did, however, create a short-term cargo surge at the California ports that stressed port capacity. In that regard frontloading can be considered one source of potential surges in the future.

Empty Container Trends

Containers move both loaded and empty. Many trade forecasts include just loaded cargo movements, as those moves generate revenue for ocean carriers and tend to grow with overall economic development and demand.

For the Seaport Plan, however, it is necessary to forecast empty container movements as well. Empty containers require just as much space on vessels, in terminals, and on highways and railroads. Although the rates charged may be lower, the work involved in moving empty containers through marine terminals is similar to the work required for loaded containers.

While loaded container movements are driven by the need to move goods between origin and destination and by routing choices in between, empty container movements typically reflect:

- Imbalances between inbound and outbound cargo flows.
- Need for specialized container types (notably refrigerated containers) in specific export regions.
- Demand for container capacity at overseas origin points.
- Space available on vessels.
- The relative cost of re-positioning empty containers by various routes.
- Strategies and policies of container fleet owners (ocean carriers and leasing companies).

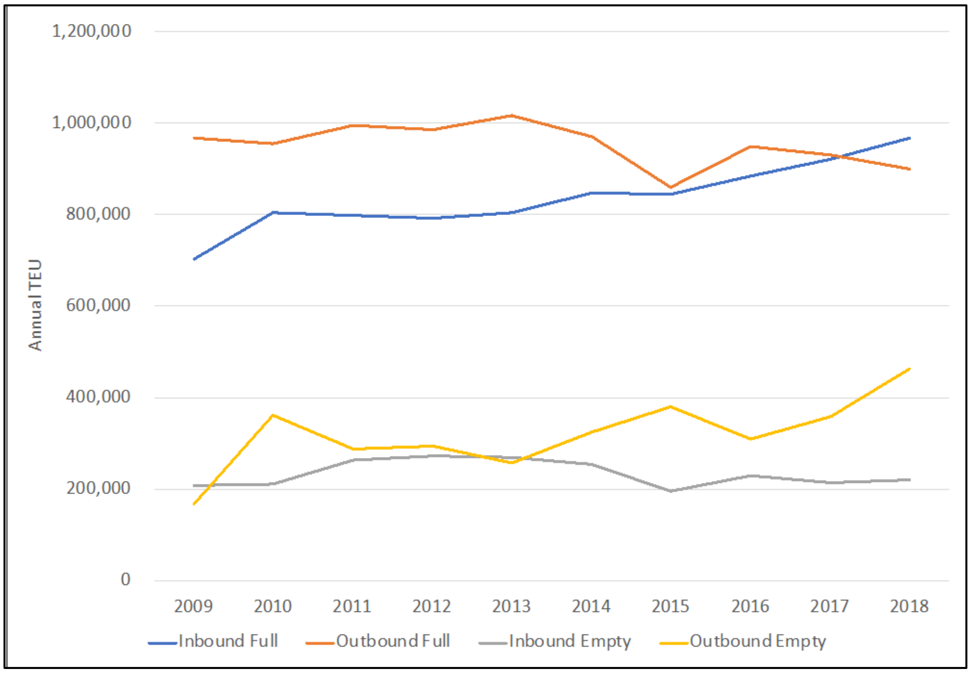
Oakland is unusual among West Coast ports in having substantial flows of both inbound and outbound empty containers (Exhibit 50). The Southern California ports, in contrast, have massive outbound empty container movements due to their import/export imbalance, and minimal inbound empties.

Exhibit 50: Port of Oakland Loaded and Empty TEU, 2009-2018

Annual Total TEU					
Year	Inbound Full	Outbound Full	Inbound Empty	Outbound Empty	Total
2009	701,501	966,882	209,258	167,570	2,045,211
2010	802,657	955,579	209,878	362,343	2,330,457
2011	797,272	993,826	264,471	286,957	2,342,526
2012	791,672	986,452	271,068	294,711	2,343,903
2013	803,314	1,014,796	270,535	257,919	2,346,564
2014	845,810	969,378	254,636	324,245	2,394,069
2015	844,234	858,146	196,677	378,464	2,277,521
2016	883,748	947,968	227,816	310,044	2,369,576
2017	919,524	930,826	213,381	357,105	2,420,837
2018	965,552	897,804	218,968	464,027	2,546,351
2010-2018 CAGR	2.3%	-0.8%	0.5%	3.1%	1.1%

The growth rates in Exhibit 50 and the patterns in Exhibit 51 imply a complex relationship between loaded and empty container moves.

Exhibit 51: Port of Oakland Total Loaded and Empty TEU Chart, 2009-2018



International Loads and Empties

Oakland's domestic and international cargo flows have different growth patterns, as noted earlier. Accordingly, the consultant team split the international and domestic empty flows for separate analysis. Exhibit 52 shows the international containerized data for 2009–2018. The 2009 recession data, grayed out in the tables, would artificially boost the apparent growth rate and has been left out of the CAGR calculations, but has been shown in the trend graphs to illustrate the port-recession changes.

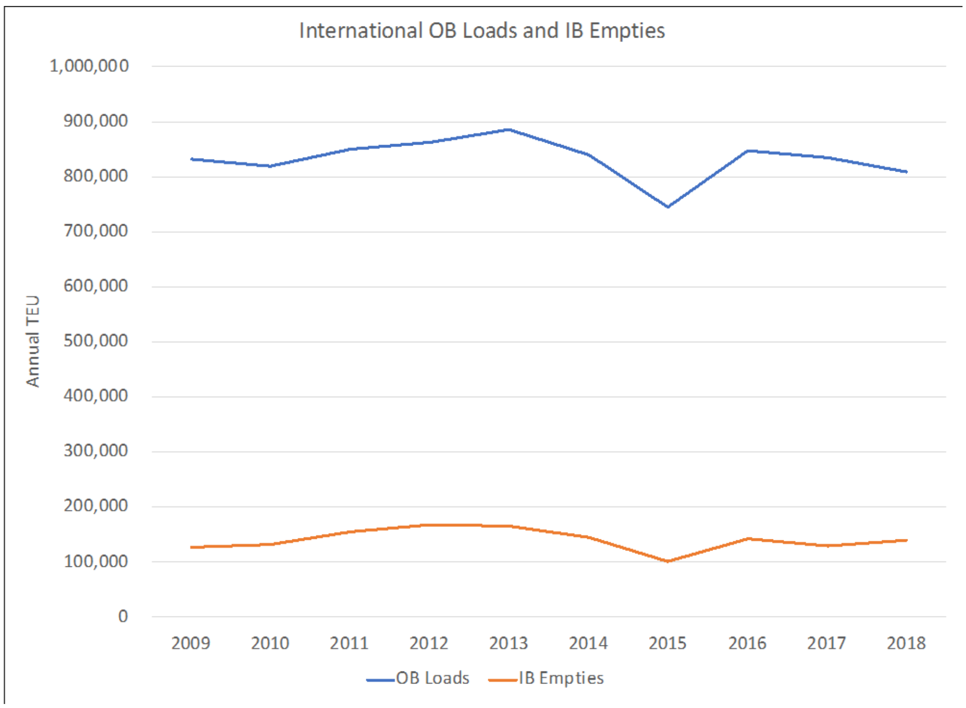
Exhibit 52: Port of Oakland International Loaded and Empty TEU, 2009-2018

Annual International TEU					
Year	Inbound Full	Outbound Full	Inbound Empty	Outbound Empty	Total
2009	644,904	830,297	127,288	165,931	1,768,420
2010	771,343	817,822	131,614	359,979	2,080,758
2011	756,338	849,162	155,045	278,023	2,038,568
2012	767,152	861,502	169,169	293,302	2,091,125
2013	778,523	886,062	165,243	256,833	2,086,661
2014	820,975	838,686	146,141	323,419	2,129,221
2015	819,406	743,282	100,327	376,706	2,039,721
2016	860,432	846,051	143,540	308,556	2,158,579
2017	896,172	833,616	129,705	355,476	2,214,969
2018	946,524	807,975	139,719	462,690	2,356,908
2010-2018 CAGR	**2.6%**	**-0.2%**	**0.7%**	**3.2%**	**1.6%**

The growth rates for inbound loads (full) and outbound empties are similar, as are those for the outbound loads and inbound empties.

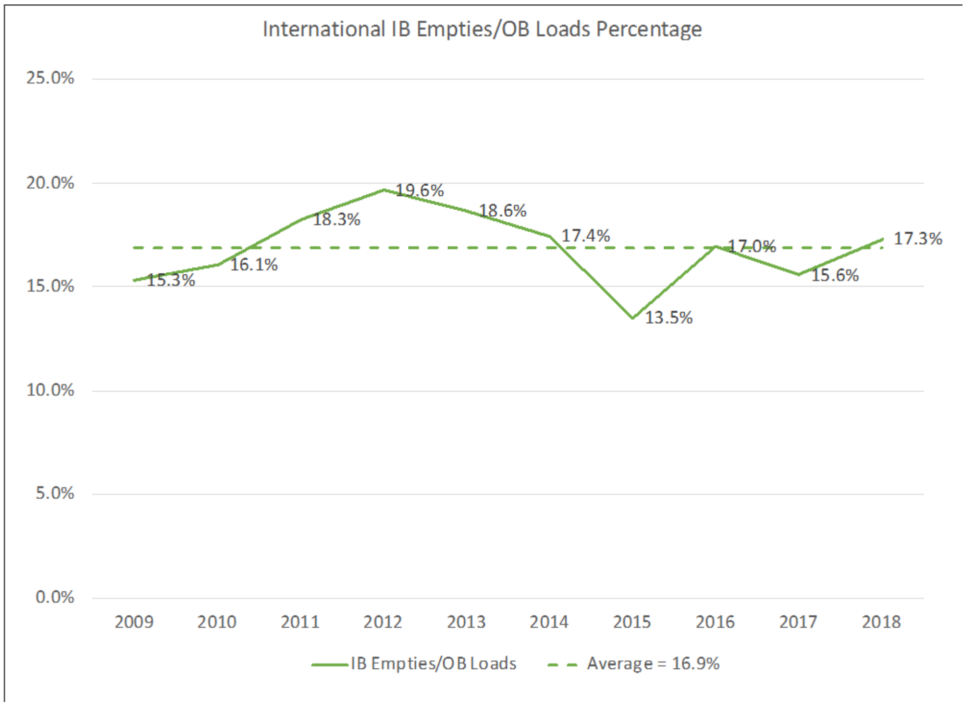
Isolating the inbound empties and the outbound loads in Exhibit 53 highlights that pattern and suggests that empties are moved inbound to supply the needs of outbound shippers – exporters. Most of the exporters' requirements are met by empty containers available locally from import loads. There are a number of reasons why an exporter may not be able to use an empty import container for an outbound load, including ownership, location, size, type, and timing. One reason for bringing in empties is to supply reefer containers for California exporters.

Exhibit 53: Port of Oakland International Outbound Loads and Inbound Empties, 2009-2018



The ratio of inbound international empties to outbound loads averaged 16.9% between 2009 and 2018. Exhibit 54 shows that the ratio has moved back and forth in a fairly narrow range with only slight upward trend (due in part to the low, recession-era value in 2009).

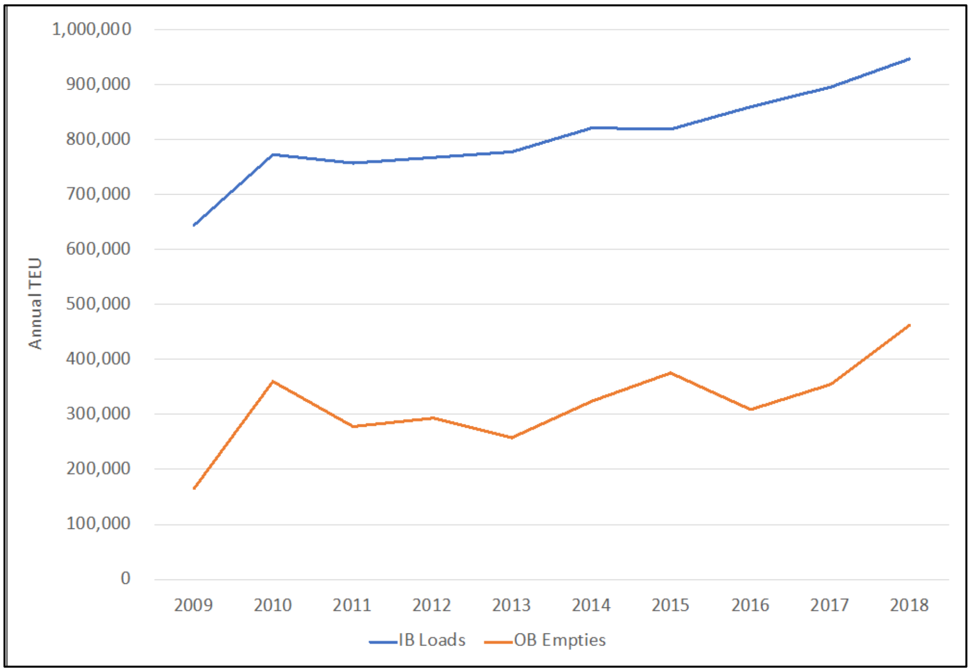
Exhibit 54: Port of Oakland Relationship of International Inbound Empties to Outbound Loads, 2009-2018



International outbound empties tend to move with international inbound loads (Exhibit 55). In most ports, outbound empties are generated by the excess of imports over exports. In Oakland there are two reasons:

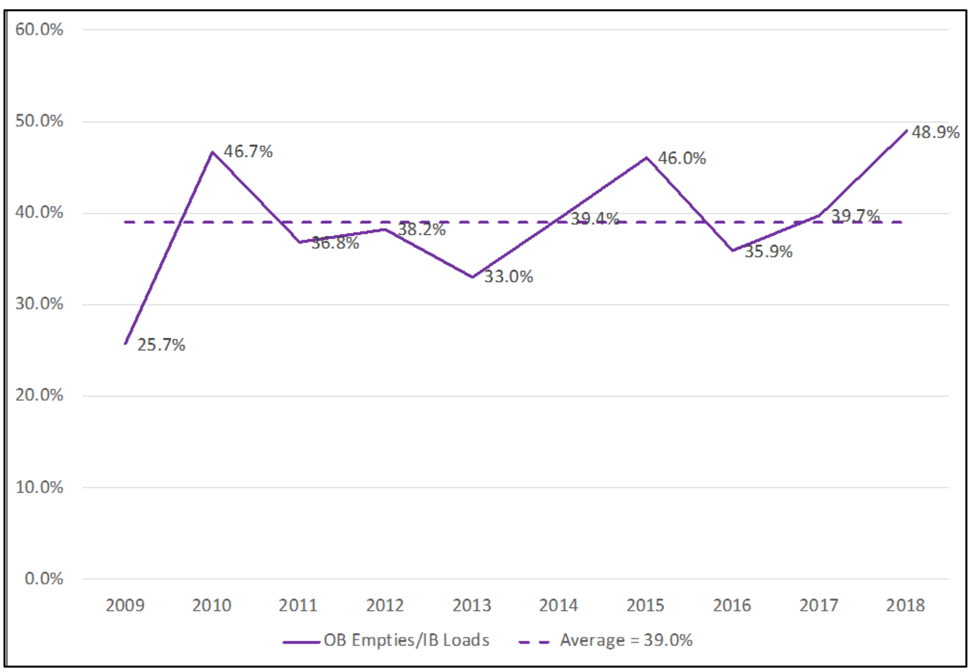
- Exporters cannot always use empty import containers for export loads, and the excess empties are returned to origin.
- Oakland is often the last West Coast port call before vessels return to Asia, so ocean carriers return excess empty containers from other areas through Oakland: 16 of the 17 services between the Far East and Oakland at the start of March had Oakland as the final West Coast call.

Exhibit 55: Port of Oakland International Inbound Loads and Outbound Empties, 2009-2018



Outbound empties averaged 39.0% of inbound loads between 2009 and 2018. Exhibit 56 again shows a slight upward trend, due mostly to inclusion of the low 2009 value.

Exhibit 56: Relationship of International Outbound Empties to Inbound Loads at Port of Oakland, 2009-2018



The net outbound international empty movement in Exhibit 57 means that Oakland has been "exporting" an average of 202,581 TEU or an estimated 115,761 containers each year. Based on contacts with ocean carriers and other stakeholders, the consultant team confirmed that at least some ocean carriers reposition empty containers from inland regions by rail to take advantage of Oakland's "last port of call" position.

Exhibit 57: Port of Oakland International Container Imbalance, 2009-2018

International Container Trade				
Year	Inbound Loaded & Empty	Outbound Loaded & Empty	Net Outbound TEU	Est. Net Outbound Containers @ 1.75
2009	772,192	996,228	224,036	128,021
2010	902,957	1,177,801	274,844	157,054
2011	911,383	1,127,185	215,802	123,315
2012	936,321	1,154,804	218,483	124,847
2013	943,766	1,142,895	199,129	113,788
2014	967,116	1,162,105	194,989	111,422
2015	919,733	1,119,988	200,255	114,431
2016	1,003,972	1,154,607	150,635	86,077
2017	1,025,877	1,189,092	163,215	93,266
2018	1,086,243	1,270,665	184,422	105,384
Average	**946,956**	**1,149,537**	**202,581**	**115,761**

Domestic Loads and Empties

Exhibit 58 shows the domestic containerized data for 2009–2018. (As was the case with the international data in Exhibit 52, the 2009 recession data is grayed out and has been left out of the CAGR calculations). Domestic service from Oakland is primarily offered by two U.S. Flag carriers (Pasha and Matson) and serves the Hawaiian market. In 2018 the two lines combined offered three calls per week. The number of loaded domestic containers handled at Oakland has decreased markedly in both directions over the last ten years, with the reduced rates for inbound loads (full) and outbound loads similar to outbound empties; only inbound empties posted growth since 2010 (although there have been declines in each of the past four years). This decrease is primarily due to an apparent loss of market share to Southern California.

Exhibit 58: Port of Oakland Domestic Loaded and Empty TEU, 2009-2018

Annual International TEU					
Year	Inbound Full	Outbound Full	Inbound Empty	Outbound Empty	Total
2009	56,597	136,585	81,970	1,639	276,791
2010	31,314	137,757	78,264	2,364	249,699
2011	40,934	144,664	109,426	8,934	303,958
2012	24,520	124,950	101,899	1,409	252,778
2013	24,791	128,734	105,292	1,086	259,903
2014	24,835	130,692	108,495	826	264,848
2015	24,828	114,864	96,350	1,758	237,800
2016	23,316	101,917	84,276	1,488	210,997
2017	23,353	97,210	83,676	1,629	205,868
2018	19,028	89,829	79,249	1,338	189,443
2010-2018 CAGR	**-6.0%**	**-5.2%**	**0.2%**	**-6.9%**	**-3.4%**

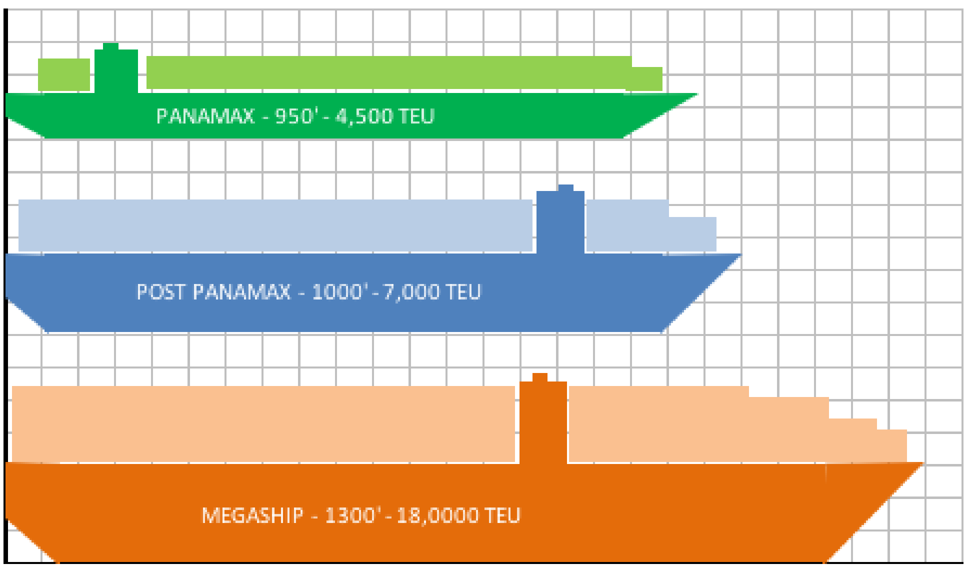
Container Vessel Size

Average and maximum container ship sizes are both increasing due to the introduction of "mega ships" with capacity of up to 22,000 TEU. Exhibit 59 shows the progression of vessel sizes, and Exhibit 60 provides a graphical comparison.

Exhibit 59: Container Vessel Sizes

Vessel	TEU Capacity	Containers Across	Containers Above/Below Deck	Draft Feet	Beam Feet	Air Draft Feet	LOA Feet	Berth Feet
Panamax	4,000	15	5/6	40	105	117	950	1,055
Post-Panamax	7,000	17	6/9	49	141	138	1,000	1,141
Post-Panamax	9,000	19	6/9	50	158	159	1,200	1,358
NeoPanamax	13,000	20	6/10	50	161	164	1,200	1,361
Megaship	**18,000**	**23**	**9/10**	**52**	**193**	**187**	**1,300**	**1,493**

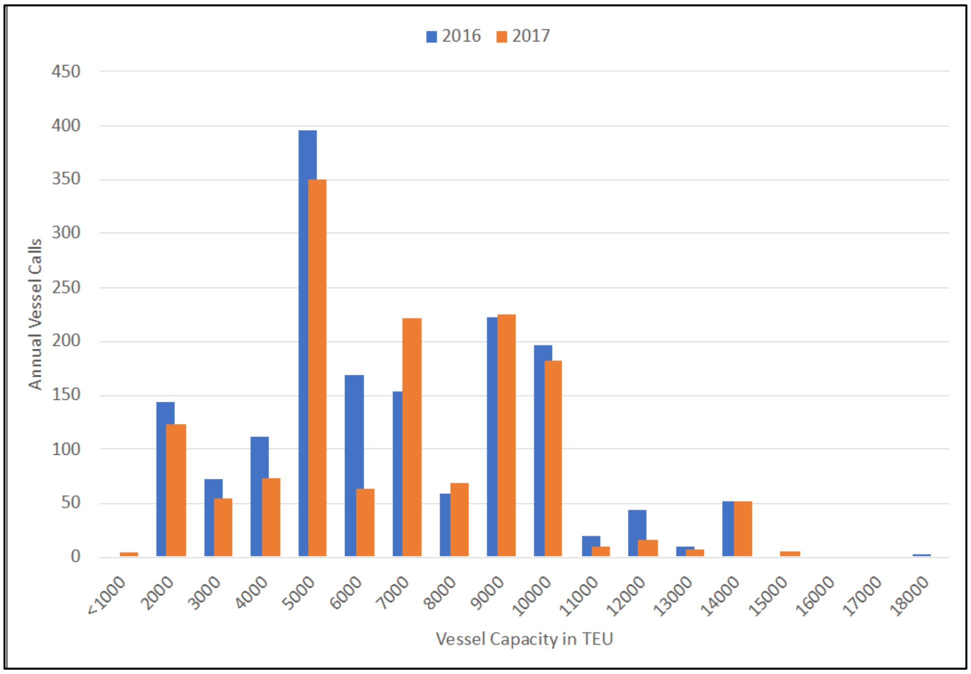
Exhibit 60: Vessel Size Graphics



The push toward larger container ships is driven by ocean carrier pursuit of scale economies in an era of low profit margins. Thus far the largest container vessels have been deployed in Asia-Europe trades, where the very long voyages can best exploit scale economies.

Exhibit 61 shows the distribution of container vessel sizes calling at Oakland in 2016 and 2017, based on data available from the federal AIS system. Because of the large number of vessels and vessel calls, the average size grows slowly - from 6,179 TEU in 2016 to 6,333 TEU in 2017. At the start of March 2019, Oakland had seven services to/from the Far East that utilized at least one vessel with a capacity of at least 10,000 TEU, of which five utilized at least one vessel with a capacity of at least 13,000 TEU and none utilized a vessel with a capacity of at least 18,000 TEU.

Exhibit 61: 2016-2017 Oakland Container Vessel Sizes



The larger vessel sizes need greater berth length. The industry rule of thumb is that a vessel requires berth space equal to its own length plus its breadth (Exhibit 62). A 1300-foot 18,000 TEU vessel, for example, would require about 1,493 feet of berth space.

Exhibit 62: Container Vessel Berth Requirements

Vessel	TEU Capacity	Vessel LOA Feet	Vessel Beam Feet	Berth Feet Required
Panamax	4,000	950	105	1,055
Post Panamax	7,000	1000	141	1,141
Megaship	18,000	1300	193	1,493

In 2017, the average length of vessels calling Oakland was 962 feet, up about 1% from 957 feet in 2016.

The APL Florida (Exhibit 63) made three Oakland calls in 2017 and is typical of the average container vessel at 6,350 TEU with a length of 961 feet, beam of 131 feet, and design draft of 40.4 feet. This vessel would require 1,092 of berth length (vessel length plus vessel beam).

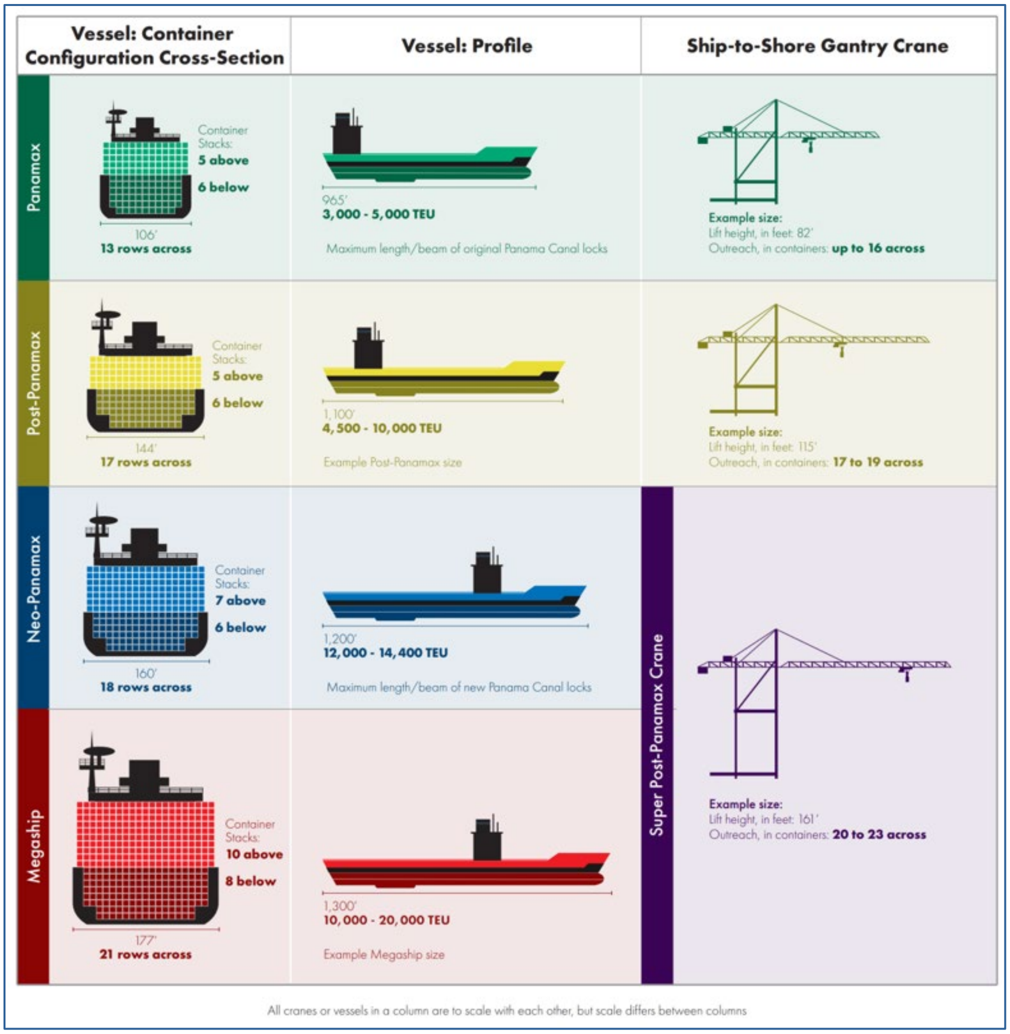
Exhibit 63: APL Florida: Typical of Oakland Vessel Calls

The largest vessel calling at Oakland in 2017 was the COSCO Himalayas, at 14,568 TEU with length of 1200 feet, beam of 168 feet, and design draft of 51 feet (Exhibit 64). This vessel would require 1,368 of berth length (vessel length plus vessel beam).

Exhibit 64: COSCO Himalayas, Largest 2017 Vessel at Oakland

Larger vessels also need more cranes, and larger cranes. As shown in Exhibit 65, so-called "super post-Panamax" cranes that serve megaships must be higher and have greater outreach.

Exhibit 65: Vessel and Crane Dimensions



Oakland's current (early 2019) crane inventory is shown in Exhibit 66.

Exhibit 66: Port of Oakland Ship-to-Shore Cranes

Terminal	Crane Type		
	Panamax	Post-Panamax	Super Post-Panamax
OICT			10
TraPac		5	2
Ben E. Nutter		1	3
Matson		4	
Berth 20-24		4	
Howard	3	1	
Total	**3**	**15**	**15**

As of April 2019, Oakland had 3 super post-Panamax cranes on order to replace three older cranes at OICT.

Marine terminals typically use more cranes to discharge and load large ships within the scheduled port call. Port terminals that discharge or load a large proportion of the vessel's capacity may use 6–7 cranes on the largest vessels. Terminals can use fewer cranes if they are handling less of the vessel's capacity or have a longer vessel call.

Larger container ships also tend to create cargo surges. The larger vessels are operated and shared by ocean carrier alliances. Mega vessel deployment may thus concentrate cargo that was formerly handled on different days, or different vessels, at different terminals in a single call at one terminal. As the data in Exhibit 67 and the chart in Exhibit 68 show, the number of vessel calls at Oakland has been decreasing despite cargo growth, and the average vessel size and container volume handled per vessel call have been rising.

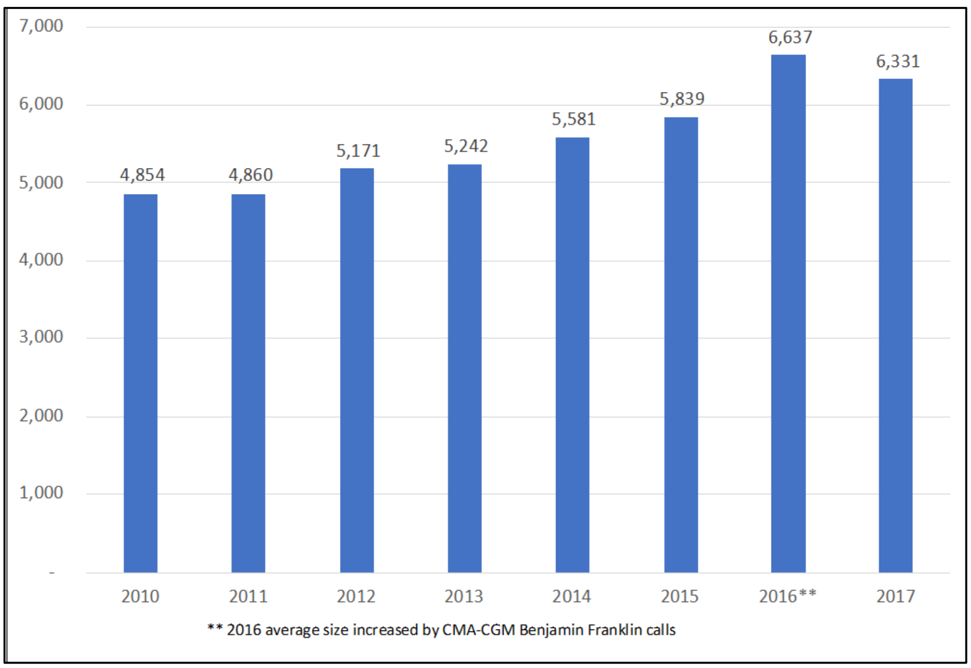
Exhibit 67: Oakland Vessel Calls and Average Cargo Volumes

Year	Container Vessel Calls	Average Vessel TEU*	Port TEU	TEU/Call
2010	1,741	4,854	2,330,457	1,339
2011	2,187	4,860	2,342,526	1,071
2012	1,635	5,171	2,343,903	1,434
2013	1,780	5,242	2,346,564	1,318
2014	1,659	5,581	2,394,069	1,443
2015	1,371	5,839	2,277,521	1,661
2016**	1,735	6,637	2,369,576	1,366
2017	1,458	6,331	2,420,837	1,660

* Vessel TEU estimated from vessel DWT in 2013-2015

** 2016 average size increased by CMA-CGM *Benjamin Franklin* calls

Exhibit 68: Average Container Vessel Size in TEU at Port of Oakland



Cargo surges create container volume peaks that can stress terminal capacity:

- Export and outbound empties are typically received and staged in the container yard before the vessel arrives and as it is being discharged.
- Inbound loaded containers are discharged and typically spend 1–5 days in the yard before being delivered to customers.

The number of containers in the terminal thus tends to peak as the vessel is being discharged.

Larger vessels also require more space to maneuver, specifically in turning basins. When the 1,310 foot Benjamin Franklin called at Oakland's OICT in 2016, the vessel required extra tug assist to be turned outside the Estuary. The Port has planned to widen the Inner Harbor turning basin to accommodate larger vessels.

Terminal Efficiency

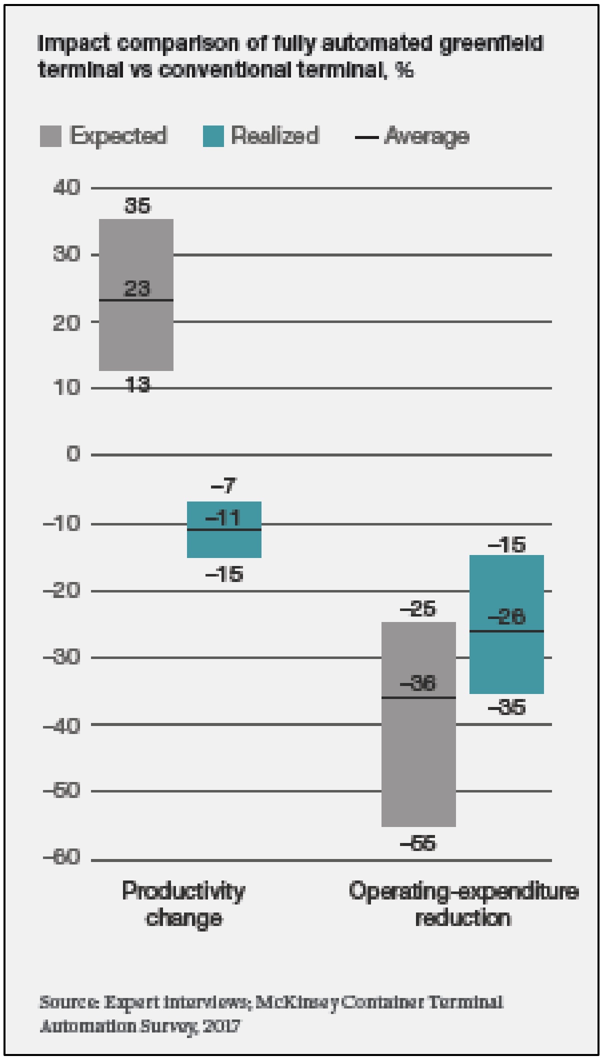
There is a worldwide trend toward greater automation in container terminals. The trend, however, is far from uniform in either its application or its implications.

"Automation" can vary from common applications such as optical character recognition (OCR) at entry gates to fully automated container yard operations with automated vehicles transferring containers to and from wharf-side gantries.

There are two "fully" automated terminals in the U.S.: the Long Beach Container Terminal (LBCT) at Long Beach and the TraPac terminal at Los Angeles. Both terminals use automated stacking cranes (ASCs) in the container yard, and automated guided vehicles (AGVs) to shuttle containers between the container yard and the manually operated container cranes. This approach to automation requires a completely new terminal (or a complete rebuild of an existing terminal) to provide tracks for the ASCs and guidance sensors embedded in the pavement for the ASCs. The total cost of the 311 acre LBCT is expected to be about $2.1 billion, including equipment, or about $6.75 million per acre. At full buildout LBCT is expected to have a capacity of 3.3 million annual TEU, or about 10,600 TEU per acre.

There are growing concerns within the industry, however, that extensive terminal automation is not generating the expected benefits. A recent report by McKinsey documented these concerns in survey responses (Exhibit 69). Respondents reported less-than-expected productivity improvements (productivity losses, actually) and less than expected cost savings.

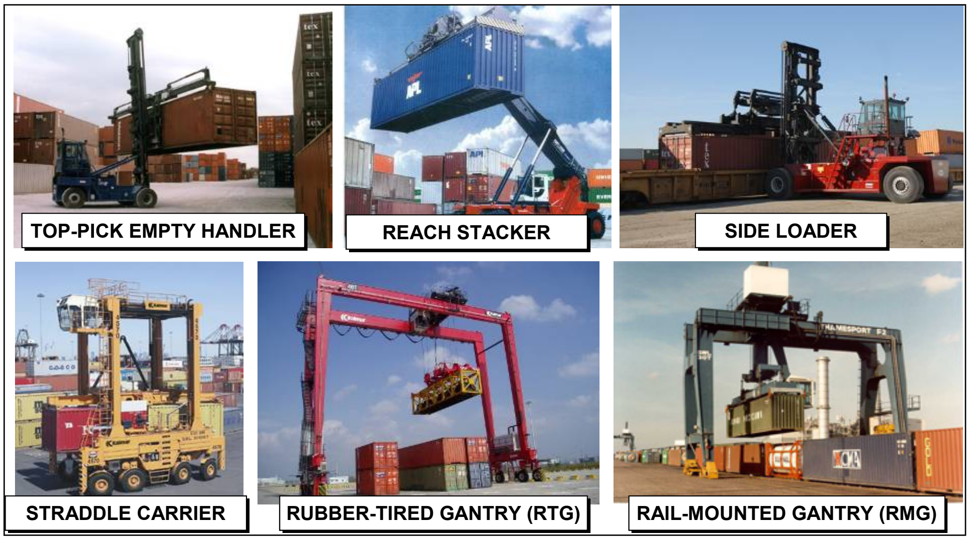
Exhibit 69: McKinsey Survey Results



Perhaps as a consequence of lower-than-expected benefits there has been a slowdown in new automation initiatives and renewed interest in less costly approaches.

Marine container terminal operators adjust container yard (CY) storage density and stacking height by reconfiguring the CY, changing handling equipment, and varying container storage practices. Typical handling equipment types are shown in Exhibit 70.

Exhibit 70: Container Yard Handling Equipment Types



APM Terminals in Los Angeles has proposed employing automated straddle carriers (auto-strads) in part of its terminal. Auto-strads do not require embedded sensors and can operate on existing pavement. However, straddle carrier operations, either automated or manned, have lower unit storage capacities than stacking cranes (Exhibit 71). Using auto-strads rather than the ASC/AGV approach at LBCT and TraPac Los Angeles lowers capital costs and should yield many of the same cost savings, but accepts reduced terminal storage capacity in exchange.

Exhibit 71: Typical CY Storage Densities

CY Storage Method	TEU Slots per Acre
Wheeled Chassis	80
Grounded Straddle Carrier	160
Grounded Stacked	200
Grounded RTG	300
Grounded RMG	360

The auto-strad technology is not yet used in North America. The leading examples are at Brisbane and Sydney, Australia.

The auto-strad strategy relies on reduced container dwell time to improve velocity and achieve comparable throughput with lower storage capacity than ASCs. Auto-strad systems require advanced information systems to inform drayage operators of container availability as soon as possible after vessel arrival. This information should, in turn, allow draymen to begin pulling import containers earlier than in other systems. The favorable results, however, still rely on the availability of sufficient drayage capacity and the ability and willingness of importers to receive the cargo.

The more comprehensive automation approaches, as at LBCT, increase capacity while reducing unit cost. The capacity increase comes from denser storage patterns and, it is hoped, reduced container dwell times. The cost reductions are achieved largely through reduced manning.

It is notable that the recent expansion and upgrade of the Oakland TraPac terminal did not include significant automation, unlike the TraPac terminal in Los Angeles.

The degree of terminal automation eventually implemented will likely depend on cargo volume. The McKinsey report found that full automation could yield substantial benefits for a "medium-sized" terminal of 6-8 million annual TEU. In 2018, Oakland's largest volume was at OICT, with 1.6 million TEU.

Container Port Competition

There has been a recent downward trend in U.S. West Coast shares of total U.S. container trade and of transpacific container trade.

The Port of Oakland handles nearly all containerized imports and exports for Northern California, as well as some intermodal cargo moving to and from inland points. Oakland competes for different trade flows in different ways.

California container ports compete with other U.S. and North American ports in two ways:

- California ports compete for "discretionary" container traffic that can move by rail to other regions through any one of several ports. For example, Oakland competes for Asian imports to Midwestern consumer markets with the ports of Los Angeles, Long Beach, Vancouver, Prince Rupert, New York-New Jersey, Baltimore, and Virginia.
- California ports compete with other regions for the location of import distribution centers (DCs) and their inbound trade flows. For example, San Joaquin County might compete with Georgia for a new import DC that would bring in goods through either Oakland or Savannah.

In the case of discretionary cargo, economic activity and employment at the port and in the transportation network are at risk due to competition with other ports. In the case of an import DC location, economic activity and employment at the DC itself are also at risk, due to competition with other regions.

For exports, Oakland's geographic position near California agricultural production gives it an advantage. Oakland is also often the last port of call before vessels return to Asia, providing a later and faster shipping option for exporters. As a result, Oakland is one of few U.S. ports where containerized exports often exceed imports.

The large local and regional markets in Southern California draw many first inbound vessel calls to Los Angeles and Long Beach. Inland importers use these vessel schedules to get the fastest service from Asia. However, Pacific Northwest and British Columbia ports have faster sailing times from ports in North Asia (e.g. Korea, Japan, Northern China), giving these ports a transit time advantage over California ports for discretionary intermodal imports. Some services call at ports in British Columbia ahead of Southern California, combining the shorter transit time with the faster vessel schedule.

There is overlap between the Oakland, Los Angeles, and Long Beach, and markets in the Central and Southern San Joaquin Valley. There, importers and exporters may choose ports based on relative trucking costs, ocean shipping, costs,ii and timing of vessel schedules.

As Exhibit 72 shows, the Pacific Coast ports combined had a 55 to 58 percent share of the loaded U.S. import container trade in 2000 through 2012. That share declined to 49 percent by 2017. This loss of market share has prompted concerns over the competitiveness of California's container ports.

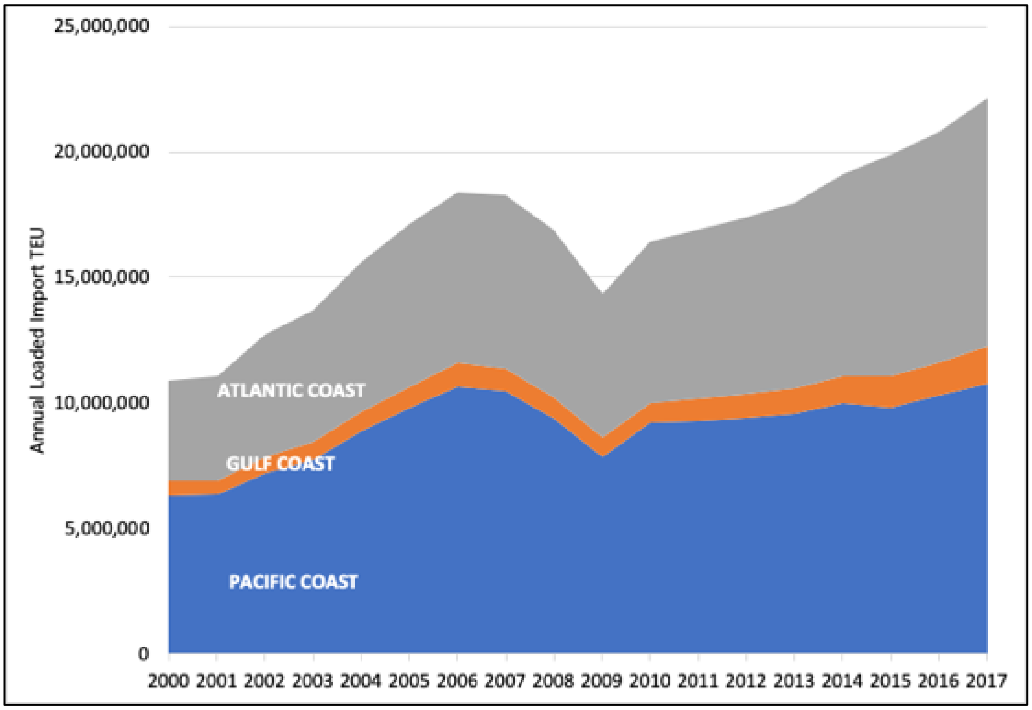
[ii] foot note

Exhibit 72: Coastal Shares of Loaded Import TEU, 2000-2017

Coast	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Pacific	58%	57%	57%	56%	57%	57%	58%	57%	55%	55%	56%	55%	54%	53%	52%	50%	50%	49%
Atlantic	37%	38%	38%	38%	38%	38%	37%	38%	39%	40%	39%	40%	40%	41%	42%	44%	44%	45%
Gulf	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	6%	6%	6%	6%	7%

As Exhibit 73 reveals, however, the market share shift did not result from net cargo loss at California or Pacific Coast ports, but from faster growth at Atlantic and Gulf Coast ports. Imports on all three coasts grew rapidly up to the peak in 2006-2007, then fell off during the 2008-2009 recession. After the recession, growth resumed on all coasts (although interrupted on the West Coast by the labor-management dispute of late 2014 and early 2015).

Exhibit 73: U.S. Loaded Import TEU by Coast, 2000-2017



There was faster growth on the Atlantic and Gulf coasts for several reasons identified in the literature and trade press:

- Strong growth in the transatlantic/European and Caribbean/South American trades served by the Atlantic and Gulf ports.
- Increased use of Suez Canal routings from Southeast Asia to the U.S., driven in part by a shift of manufacturing and sourcing from China to Southeast Asia and the Indian subcontinent.
- Increased adoption of "three corner"[iii] and "four corner"[iv] logistics strategies by large importers (notably large retail chains), which dispersed import flows from the major Southern California gateway.
- A reduction in Southern California import transloading.
- Rate increases on rail intermodal service, leading ocean carriers to replace rail movements from Southern California to some inland markets with truck or rail moves from other ports.

iii Using three import ports, such as Los Angeles, Savannah, and New York-New Jersey
iv Using four import ports, such as Los Angeles, Seattle, Savannah, and New Yok-New Jersey

- Rising costs of locating and operating distribution and manufacturing facilities in California, versus aggressive economic development efforts in other states like Texas and Alabama.
- Modernization and increased capacity at Atlantic and Gulf ports.
- New Panama Canal locks permitting larger, more efficient vessels on that route.
- Increased cost at California ports due to "clean truck" requirements, PierPass/Off-Peak fees, and rising drayage costs from port and highway congestion.
- Concern over West Coast labor relations stability after the lengthy 2014-2015 dispute and accompanying shipping disruption.

Of these factors, only the last two are specific to California ports; the others are shifts in trade patterns and in the economic context in which California ports must compete.

Exhibit 74 provides a key perspective on the relative growth of California's container port volumes. In the rapid growth era of 1990-2007, Southern California ports outperformed the nation. Much of the cargo and share growth in that period was attributable to the rapid expansion of rail intermodal container movements through San Pedro Bay in response to the introduction and adoption of double-stack rail cars. This period also saw an increase in the practice of import transloading: bringing in international containers of imported merchandise and transferring the goods to domestic containers or trailers in Southern California. Finally, this period also saw dramatic growth in U.S. imports from China, with Southern California as the leading gateway. The Port of Oakland did not benefit as much from the expansion of intermodal traffic or transloading, and Northern California[v] TEU totals did not grow as quickly.

Exhibit 74: Container Port Cargo Growth Rates 1990-2017

Compound Average Growth Rate (CAGR)	1990-2007	2007-2009	2009-2017
U.S.	6.4%	-6.1%	4.4%
California	7.9%	-8.4%	4.3%
Southern California	8.9%	-8.9%	4.6%
Northern California	3.8%	-5.0%	2.1%
Pacifc Northwest	3.6%	-8.1%	1.4%
British Columbia	11.7%	-1.3%	7.1%

U.S. container ports were hit hard by the 2008-2009 recession. Oakland's volume dropped by 14 percent during the recession but did not grow as quickly after partial recovery in 2010. The labor-management issues in late 2014 and early 2015 hampered recovery for all U.S. West Coast ports.

Exhibit 74 also highlights one other critical factor: the rapid growth of the British Columbia ports as an intermodal gateway to both Canadian and U.S. markets. Much of the market share gained by the British Columbia ports has come at the expense of U.S. Pacific Northwest ports (as suggested by their slow post-recession growth in Exhibit 74 and the loss of regular international container service at the Port of Portland in Oregon), but the success of Vancouver and Prince Rupert has restrained Oakland's discretionary cargo growth as well. Prior to the recession, the Port of Oakland added the BNSF-served Oakland International Gateway (OIG) to increase capacity for expected growth in discretionary cargo. That growth was slower than had been hoped, in part due to persistent competition from Southern California ports and new competition from British Columbia ports.

[v] The Port of San Francisco also handled containers until 2013.

Scenario Overview

The complex mix of international and domestic containers combined with the varied ratio of loaded and empty containers requires separate modeling of the international and domestic forecasts.

International Loaded Containers

The loaded forecast from 2020 onward utilizes separate models for imports and exports that are driven by forecast variables purchased from Moody's. The 2019 projection is based on the short-term model that drives the Global Port Tracker forecast, which has separate sub-models for each direction of trade on the Port's primary trade routes.

Short term growth adjustments

The forecast scenarios incorporate adjustments for the first five years of the forecast (2019-2025).

The moderate growth forecast anticipates that the Port of Oakland would add three "first call services" (i.e. the Port of Oakland is the first North American port of call) in 2022-2024 to provide a first call service for each of the three major vessel sharing alliances. These first call services would decrease the transit time for cargo coming from Asia and reduce the impact of late vessel arrivals caused by delays at previous ports. The impact of these new services is spread across a three-year period, in part due to the timing of when shipping lines introduce schedule changes and in part due to the associated ramp-up in volume that would likely occur.

The slow growth forecast anticipates that the current slowdown in economic growth is greater than in the moderate case. Total volumes in the low growth scenario reach a low in 2021 while the moderate scenario reaches a low in 2020.

The strong growth forecast anticipates that any slowdown is offset by the Port of Oakland acquiring three first call services earlier than in the Moderate Case, in 2020-2022. An additional three first call services are acquired between 2030 and 2032 in the strong growth scenario.

Discussions with Port of Oakland officials suggested that a first call service would increase import volumes by 50,000 to 100,000 TEU. Based on a detailed comparison of vessel call volumes and average vessel sizes, the import/export mix, and the share moved inland via rail at Los Angeles, Long Beach, and Oakland, the consultant team estimated that each first call schedule that replaced an existing schedule would add 74,151 annual TEU (roughly the average of the Port staff estimate).

- The Moderate Case allows for introduction of first call services in 2022–2024, timed roughly to coincide with projected ramp-up of Tesla vehicle production passing 300,000 annual vehicles.

- The Strong Growth Case forecast included the introduction of first call vessels earlier, in 2020–2022, and a second wave in 2030-2032.

An event such as the ramp-up of Tesla production is likely to markedly increase demand for first call delivery of high-priority imports – auto parts, in Tesla's case. When New United Motors Manufacturing, Inc. (NUMMI, Tesla's predecessor at the Fremont plants) was operating near capacity, there was at least one first call vessel service (APL) to serve that business, and likely others. The projected Tesla ramp-up is not necessarily a "make or break" event for first-call service; it is representative of the type of demand likely to receive first call service.

Long term growth adjustments

The growth rates in the Moderate Growth case serve as the basis of the forecast in the slow growth and strong growth scenarios, but these are modified to represent the combination of a number of variables that may impact container volumes in the long term (2024-2050). The variables that in general may impact the slow growth and strong growth scenarios include:

- Slower/faster population growth in the U.S.;
- Slower/faster economic growth in the U.S.;
- Major infrastructure investment by the U.S. Government;
- Lower value of the U.S. dollar resulting in increased export growth;
- High value of the U.S. dollar resulting in decreased export growth;
- Changes in trade policies that increase/decrease tariffs resulting in reduced/increased import volume;
- Increased/decreased market share compared to other West Coast ports in the U.S. and Canada, resulting in increased/reduced import and export volume (which could be driven by infrastructure spending/underfunding, regional economic performance, improved/reduced port productivity, etc.); and
- Increased/decreased market share at West Coast ports compared to East Coast ports, resulting in increased/reduced import and export volume (which could be driven by geopolitical events, changes in transportation costs due to fuel prices or emission requirements, improving/slowing economic growth in trade partners, etc.).

Import volumes at container ports are significantly impacted by the creation of new distribution centers, especially if they are designed to process and distribute imports to other smaller distribution centers. Walmart, for example, has six such facilities that are located near major ports including the Ports of Los Angeles, Long Beach, Houston, Savannah, and Virginia. New distribution centers designed to serve Northern California stores directly or other regional distribution centers would likely increase imports to the Port of Oakland.

Potential scenarios for distribution center-related higher growth include:

- Target has major distribution centers in both Northern California (Woodland) and Southern California (Inland Empire). The addition of a first call vessel at Oakland might shift some cargo from the Ports of Los Angeles and Long Beach to the Port of Oakland as the company decides to serve more of their central California stores from Northern rather than Southern California.

- Walmart has California DCs in Mira Loma (inland empire) and Porterville (SE of Fresno). Porterville is almost exactly equidistant between the Ports of Los Angeles and Long Beach and the Port of Oakland. Most intact Walmart imports come through the Southern California ports, while a separate stream of imports is transloaded at DAMCO in South Gate north of Long Beach. Walmart might decide to import more cargo via Oakland to give themselves a gateway option.

The moderate growth scenario assumes that:

- The trade disputes with China, the European Union, Canada, and Mexico are resolved amicably without punitive long-term tariffs and most trade flows return to their pre-dispute growth patterns;

- California exporters already impacted by the trade dispute with China or other events that have negatively impacted the export market either regain those former markets or instead find new markets for the same output (perhaps at a lower price);

- Long term exports rebound as foreign markets recover economically;

- A positive impact on refrigerated container trade due to the development of the Cool Port facility; and

- A moderate increase in the import of automobile parts as Tesla increases production.

The moderate growth international TEU forecasts for imports and exports are driven by projections of economic growth developed by Moody's and Caltrans, including sub-components of national-level Gross Domestic Product, industrial output, and Gross Metro Product.

The slow growth scenario assumes that some of the following occur, thereby negatively impacting the growth in international container trade:

- Slower import demand in line with the low end of relevant economic and trade forecasts, starting from a resumption of 2017 levels rather than from the late 2018 peak that was supported by retailers bringing in cargo ahead of feared tariffs;

- A permanent loss of a portion of the U.S. and California export markets as other suppliers capture market share during protracted trade wars;

- Global economic growth slows at the higher end of relevant economic and trade forecasts or recovers at the lower end of those forecasts; or

- There is only a small increase in the import of automobile parts as Tesla increases production.

The strong growth scenario assumes that some of the following occur, thereby increasing growth in international container trade:

- Import demand in line with the high end of relevant economic and trade forecasts, starting from a resumption of 2017 levels rather than from the late 2018 peak that was supported by retailers bringing in cargo ahead of feared tariffs;

- Trade disputes are resolved in a way that greater international trade is encouraged;

- New distribution centers are built that rely on imports through the Port of Oakland;

- Global economic growth slows at the lower end of relevant economic and trade forecasts or recovers at the higher end of those forecasts; or

- There is a large increase in the import of automobile parts as Tesla increases production.

Exhibit 75 compares the moderate, slow, and strong growth scenarios for the forecasts for loaded containerized imports and exports.

Exhibit 75: Projected International Loaded Imports and Exports to the Port of Oakland by Scenario

Year	Imports			Exports			Total International Loads		
	Moderate	Slow	Strong	Moderate	Slow	Strong	Moderate	Slow	Strong
2010	771,343	771,343	771,343	817,822	817,822	817,822	1,589,165	1,589,165	1,589,165
2018	946,524	946,524	946,524	807,975	807,975	807,975	1,754,499	1,754,499	1,754,499
2020	972,705	934,088	1,024,188	804,645	780,666	861,775	1,777,349	1,714,755	1,885,962
2030	1,407,818	1,068,308	1,531,287	964,799	935,225	1,129,131	2,372,618	2,003,534	2,660,418
2040	1,855,070	1,338,879	2,407,678	1,108,241	1,021,749	1,363,333	2,963,311	2,360,627	3,771,011
2050	2,493,437	1,711,630	3,401,708	1,236,308	1,084,096	1,598,657	3,729,745	2,795,726	5,000,365
2018-2050 CAGR	3.1%	1.9%	4.1%	1.3%	0.9%	2.2%	2.4%	1.5%	3.3%

International Empty Containers

The empty TEU forecast is built upon the loaded TEU forecast and the concept that the volume of empty containers is related to the volume of loaded containers moving in the opposite direction. For example, as loaded inbound containers increase empty outbound containers also increase, and vice versa. The model maintains a constant loaded/empty ratio that is based on the Oakland average ratios of outbound loaded containers to inbound empty containers and inbound loaded containers to outbound empty containers over the past 10 years. This ratio equates to approximately 17 inbound empty containers for every 100 outbound loaded containers, and 39 outbound empty containers for every 100 inbound loaded containers.

The slow and strong growth empty container scenarios use the same ratios as the Moderate Case scenario, and the decrease or increase in volume is directly related to the same shift projected in the loaded container scenarios.

Exhibit 76 compares the moderate, slow, and strong growth scenarios for the forecasts for empty containerized imports and exports.

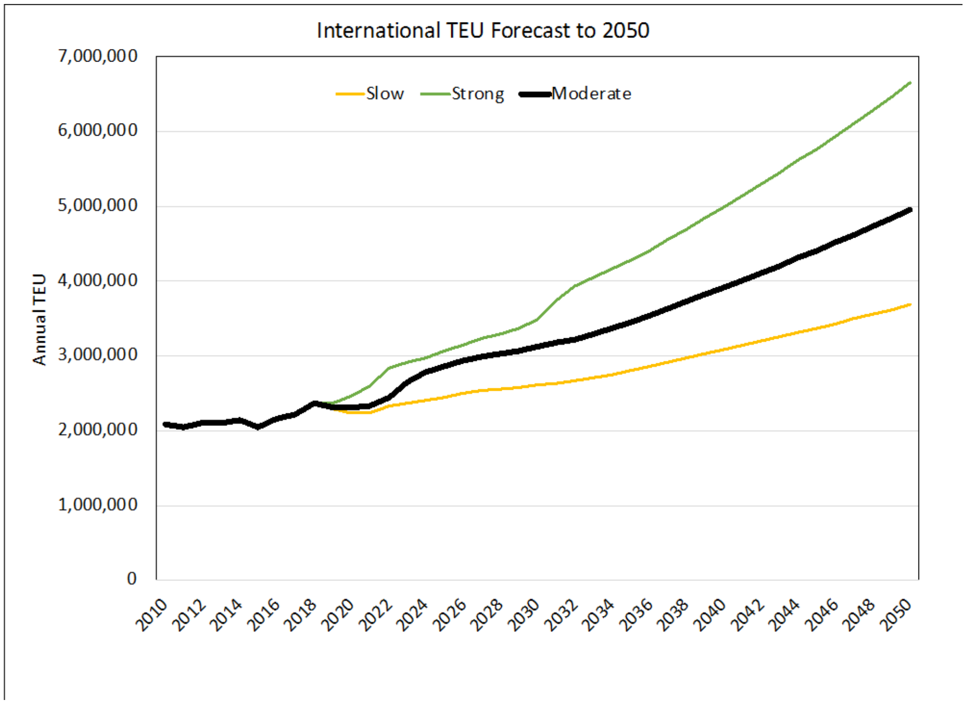
Exhibit 76: Projected International Empty Imports and Exports to the Port of Oakland by Scenario

Year	Imports			Exports			Total International Empties		
	Moderate	Slow	Strong	Moderate	Slow	Strong	Moderate	Slow	Strong
2010	131,614	131,614	131,614	359,979	359,979	359,979	491,593	491,593	491,593
2018	139,719	139,719	139,719	462,690	462,690	462,690	602,409	602,409	602,409
2020	137,128	133,041	146,864	393,867	378,231	414,714	530,995	511,272	561,578
2030	164,421	159,381	192,427	570,054	432,579	620,048	734,475	591,960	812,475
2040	188,866	174,126	232,339	751,155	542,139	974,917	940,021	716,265	1,207,256
2050	210,692	184,752	272,443	1,009,642	693,073	1,377,419	1,220,334	877,825	1,649,862
2018-2050 CAGR	1.3%	0.9%	2.1%	2.5%	1.3%	3.5%	2.2%	1.2%	3.2%

Total Containerized Cargo

Exhibit 77 shows the annual growth rates for the three forecasts for total containerized cargo.

Exhibit 77: Port of Oakland International TEU Forecast to 2050



As the chart indicates, there is expected to be a near-term divergence due to:

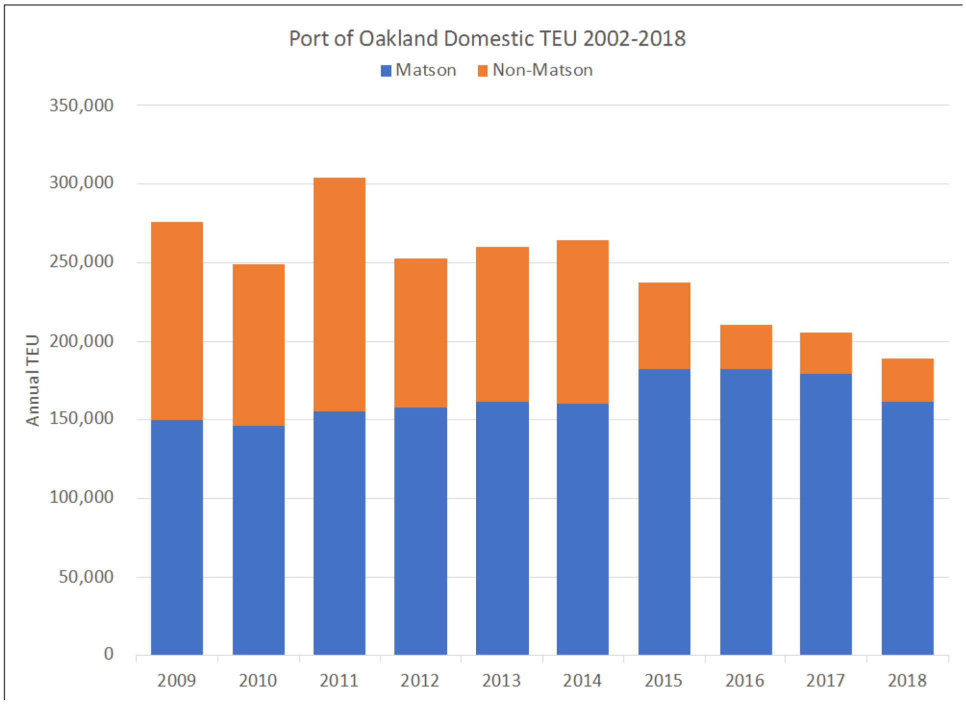
- Gradual introduction of first call services in the Moderate Case.
- More rapid introduction of first call services in the Strong Case.
- No first call services and adverse impacts of trade conditions in the Slow Case.

Thereafter, each forecast case grows at an appropriate long term rate, although as previously noted the Strong Growth scenario benefits from a second round of first call services in the mid-term.

Domestic Containers

Domestic container volumes between the Port of Oakland and Hawaii are more opaque and likely are driven primarily by market share shifts than economic growth. As previously noted, overall domestic TEU volume has decreased since 2010. However, Matson has experienced growth in its loaded outbound container volumes and empty container volumes over the same period (Exhibit 78).

Exhibit 78: Port of Oakland Domestic TEU 2009-2018



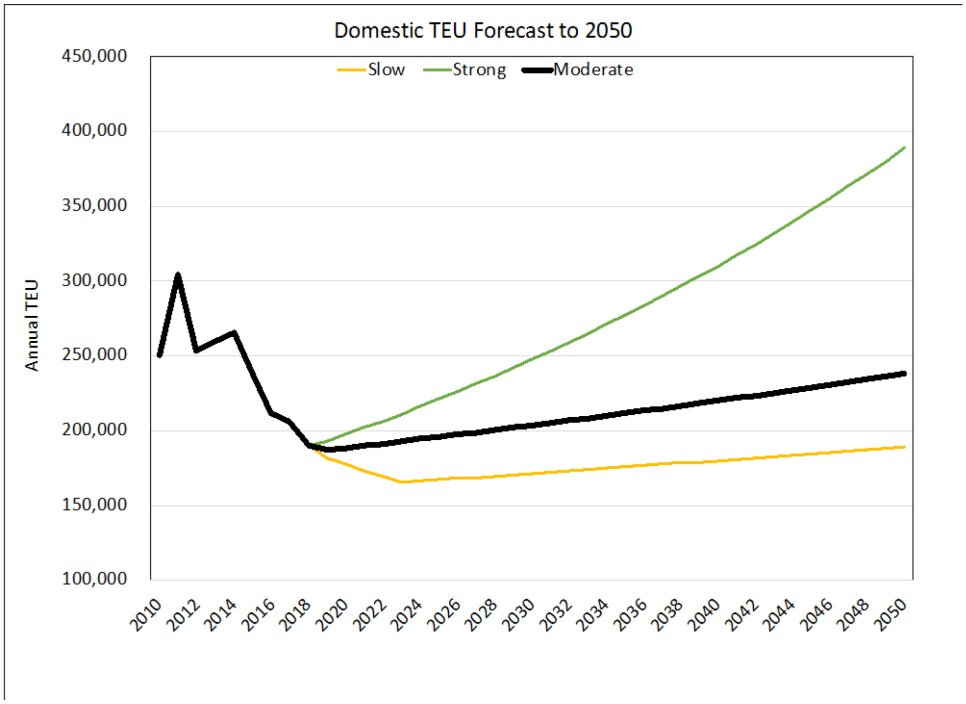
The domestic moderate growth forecast assumes that Matson continues to expand its trade volumes at the same pace as it has since 2010 while other carriers remain at the same level as 2018.

The slow growth forecast projects that Matson's cargo volume expands at the slower pace than in the Moderate Case, but that container levels at other carriers continue to decrease until Matson is the sole domestic carrier by 2023.

The strong growth forecast projects that Matson's cargo volume expands at a faster pace than the Moderate Case, using the growth the carrier experienced between 2010 and 2017 as a basis for future growth. Other domestic carriers also increase at a faster pace than in the Moderate Case and are able to capture 15% of the total domestic market each year.

Exhibit 79 charts the domestic TEU forecast.

Exhibit 79: Port of Oakland Domestic TEU Forecast to 2050



Total Containerized Cargo Forecast

The combined international and domestic forecasts are summarized at two-year intervals in Exhibit 80 and graphed in Exhibit 81. Exhibit 83 details the TEUs by trade direction and load/empty status by commodity type by decade and the long-term compound annual growth rates.

The projected 2050 totals are:

- Slow growth forecast: 3.86 million TEU as a CAGR of 1.3%
- Moderate growth forecast: 5.19 million TEU at a CAGR of 2.2%
- Strong growth forecast: 7.04 million TEU at a CAGR of 3.2%

The Moderate Case CAGR at 2.2% is slightly higher than the past average of about 2.1% due to the long-term increase in Northern California manufacturing and distribution, and to the introduction of first call vessels to serve that increase. Exhibit 82 shows the comments for the moderate growth scenario. Each of the three components allow for somewhat faster growth than the 2010-2018 record, but the slower growth of the export and domestic sectors keeps the overall rate below the import growth expectation. Exhibit 83 provides additional forecast detail.

Exhibit 67: Total TEU Forecast

Forecast	2018	2020	2021	2022	2024	2026	2028	2030	2032	2034	2036	2038	2040	2042	2044	2046	2048	2050	CAGR
International TEU																			
Moderate Growth	**2,356,908**	**2,308,344**	**2,318,804**	**2,442,863**	**2,784,004**	**2,917,894**	**3,026,614**	**3,107,092**	**3,214,886**	**3,356,776**	**3,525,303**	**3,713,425**	**3,903,333**	**4,103,788**	**4,301,247**	**4,501,782**	**4,719,250**	**4,950,079**	**2.3%**
Slow Growth	2,356,908	2,226,027	2,223,119	2,329,354	2,395,752	2,483,893	2,552,470	2,595,494	2,658,153	2,744,254	2,846,733	2,962,196	3,076,892	3,196,205	3,310,340	3,423,772	3,545,545	3,673,551	**1.4%**
Strong Growth	2,356,908	2,447,540	2,593,456	2,825,917	2,968,660	3,141,582	3,292,208	3,472,893	3,933,526	4,149,433	4,403,569	4,687,228	4,978,267	5,288,616	5,600,850	5,923,020	6,274,255	6,650,228	**3.3%**
Domestic TEU																			
Moderate Growth	**189,443**	**188,082**	**189,529**	**190,988**	**193,944**	**196,954**	**200,016**	**203,133**	**206,305**	**209,534**	**212,819**	**216,163**	**219,566**	**223,030**	**226,555**	**230,142**	**233,793**	**237,509**	**0.7%**
Slow Growth	189,443	177,159	173,131	169,107	165,912	167,575	169,255	170,952	172,666	174,397	176,145	177,911	179,694	181,496	183,315	185,153	187,009	188,884	**0.0%**
Strong Growth	189,443	197,064	201,571	206,181	215,719	225,698	236,139	247,062	258,491	270,449	282,960	296,050	309,746	324,074	339,066	354,751	371,162	388,332	**2.3%**
Total TEU																			
Moderate Growth	**2,546,351**	**2,496,427**	**2,508,332**	**2,633,850**	**2,977,949**	**3,114,848**	**3,226,630**	**3,310,226**	**3,421,191**	**3,566,310**	**3,738,122**	**3,929,589**	**4,122,899**	**4,326,818**	**4,527,802**	**4,731,924**	**4,953,044**	**5,187,588**	**2.2%**
Slow Growth	2,546,351	2,403,186	2,396,250	2,498,461	2,561,664	2,651,468	2,721,725	2,766,446	2,830,818	2,918,651	3,022,878	3,140,107	3,256,587	3,377,701	3,493,655	3,608,925	3,732,554	3,862,435	**1.3%**
Strong Growth	2,546,351	2,644,604	2,795,027	3,032,098	3,184,379	3,367,280	3,528,346	3,719,955	4,192,018	4,419,882	4,686,529	4,983,278	5,288,013	5,612,690	5,939,916	6,277,771	6,645,418	7,038,560	**3.2%**

Exhibit 81: Port of Oakland Total Containerized TEU Forecast to 2050

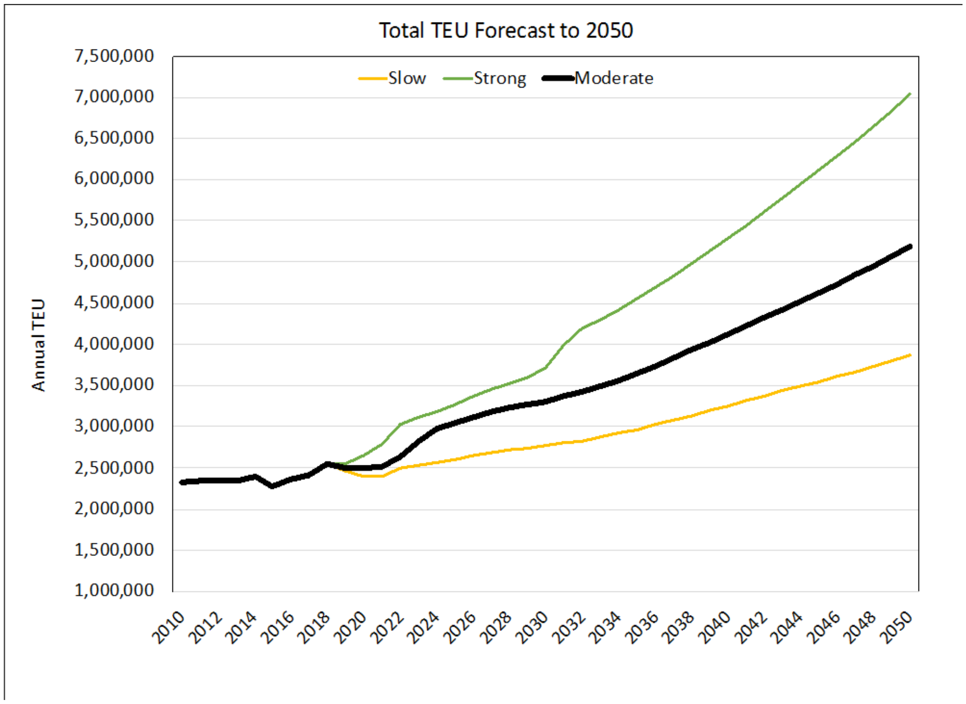


Exhibit 82: Port of Oakland Moderate Container Forecast Components

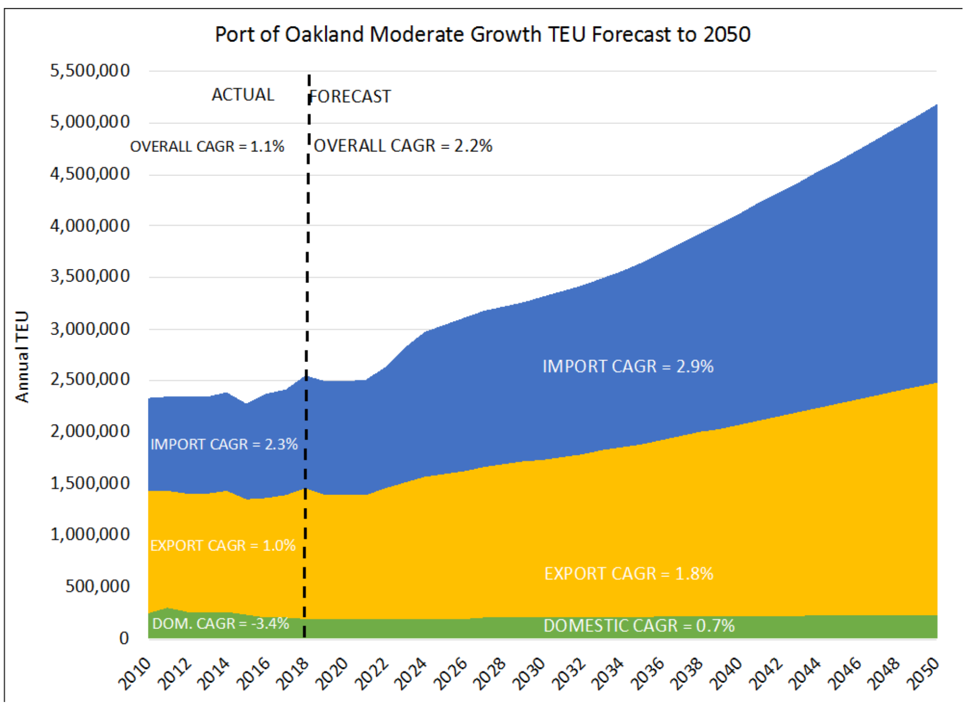


Exhibit 70: Port of Oakland Total Containerized TEU Forecast by Decade to 2050

Moderate	International				Domestic				Total
	Loaded Imports	Empty Imports	Loaded Exports	Empty Exports	Loaded Inbound	Empty Inbound	Loaded Outbound	Empty Outbound	
2010	771,343	131,614	817,822	359,979	31,314	78,264	137,757	2,364	2,330,457
2018	946,524	139,719	807,975	462,690	19,028	79,249	89,829	1,338	2,546,351
2020	972,705	137,128	804,645	393,867	19,250	76,289	91,249	1,294	2,496,427
2030	1,407,818	164,421	964,799	570,054	20,423	82,615	98,737	1,358	3,310,226
2040	1,855,070	188,866	1,108,241	751,155	21,703	89,523	106,912	1,428	4,122,899
2050	2,493,437	210,692	1,236,308	1,009,642	23,101	97,064	115,839	1,505	5,187,588
2018-2050 CAGR	3.1%	1.3%	1.3%	2.5%	0.6%	0.6%	0.8%	0.4%	2.2%

Slow	International				Domestic				Total
	Loaded Imports	Empty Imports	Loaded Exports	Empty Exports	Loaded Inbound	Empty Inbound	Loaded Outbound	Empty Outbound	
2010	771,343	131,614	817,822	359,979	31,314	78,264	137,757	2,364	2,330,457
2018	946,524	139,719	807,975	462,690	19,028	79,249	89,829	1,338	2,546,351
2020	934,088	133,041	780,666	378,231	16,561	72,804	86,744	1,050	2,403,186
2030	1,068,308	159,381	935,225	432,579	13,319	71,855	85,050	728	2,766,446
2040	1,338,879	174,126	1,021,749	542,139	14,000	75,529	89,400	765	3,256,587
2050	1,711,630	184,752	1,084,096	693,073	14,716	79,392	93,972	805	3,862,435
2018-2050 CAGR	1.9%	0.9%	0.9%	1.3%	-0.8%	0.0%	0.1%	-1.6%	1.3%

Strong	International				Domestic				Total
	Loaded Imports	Empty Imports	Loaded Exports	Empty Exports	Loaded Inbound	Empty Inbound	Loaded Outbound	Empty Outbound	
2010	771,343	131,614	817,822	359,979	31,314	78,264	137,757	2,364	2,330,457
2018	946,524	139,719	807,975	462,690	19,028	79,249	89,829	1,338	2,546,351
2020	1,024,188	146,864	861,775	414,714	15,442	82,086	98,606	931	2,644,604
2030	1,531,287	192,427	1,129,131	620,048	19,359	102,913	123,624	1,167	3,719,955
2040	2,407,678	232,339	1,363,333	974,917	24,271	129,023	154,989	1,463	5,288,013
2050	3,401,708	272,443	1,598,657	1,377,419	30,429	161,758	194,312	1,834	7,038,560
2018-2050 CAGR	4.1%	2.1%	2.2%	3.5%	1.5%	2.3%	2.4%	1.0%	3.2%

Container Terminal Capacity

Productivity Benchmarks

Exhibit 84 shows an overall comparison of average TEU/acre for major U.S. container ports. Oakland's current productivity is high, right behind New York-New Jersey.

Exhibit 84: Port Productivity Comparison

Port	Container Terminal Acres	TEU	TEU/Acre
Boston	90	270,881	3,010
Houston	811	2,459,107	3,032
Virginia	896	2,841,016	3,171
Baltimore	294	962,484	3,274
Savannah	1,200	4,046,212	3,372
Mobile	90	318,889	3,543
Seattle/Tacoma	1,011	3,665,329	3,625
Charleston	597	2,177,550	3,647
Oakland (2018)	**595**	**2,537,400**	**4,265**
New York & New Jersey	1,496	6,710,817	4,486
Long Beach	1,399	7,544,507	5,393
Los Angeles	1,704	9,343,192	5,483
12-port Average	**10,183**	**42,877,384**	**4,211**

There are many variations in marine container terminal operations and capacities.

- **Wheeled.** "Wheeled" operations, in which containers are placed on chassis and parked, have the lowest capacity per acre but also the lowest operating cost. West Coast terminals were mostly wheeled until ocean carriers began withdrawing from chassis supply, starting in 2010. Most terminals retain a portion of their wheeled operations for special handling, such as for refrigerated cargo.

- **Stacked.** Most U.S. container terminals are now largely stacked, using a variety of lift equipment to handle containers without chassis and storing the chassis separately. Stacked terminals have higher throughput per acre than wheeled terminals, but also higher operating cost due to the additional handling.

Conventional terminals, as discussed in this analysis, include wheeled, stacked, and mixed terminals, including all existing Oakland terminals. These terminals may include some aspects of automation such as the use of optical character recognition (OCR) at entry gates, but all container operations are performed with manually operated equipment.

High productivity terminals also come in multiple variations, depending on the type and extent of automation.

- **Semi-automated terminals.** Some terminals, such as the Virginia International Gateway at Portsmouth, VA, combine automated and manned operations throughout the terminal. Others, such as TraPac at Los Angeles, have sections of the terminal automated and other sections manned.

- **Auto-strad terminals.** "Auto-strads" are automated straddle carriers. This type of automation is used in Australia and is receiving increased industry attention for its lower capital cost and its capability of deployment in existing, rather than newbuilt terminals. APM Terminals has proposed deploying auto-strads in a portion of its Los Angeles terminal.

These less-than-complete automation approaches are viewed by many observers as being more cost-effective than more elaborate automation, especially for improving existing terminals. For this analysis we have grouped these approaches as "high productivity."

- **Complete automation.** The more aggressive automation approaches are often referred to as "complete automation," although the label is a misnomer. In all North American examples to date, such as the Long Beach Container Terminal (LBCT) at Long Beach, the shipside container cranes are manned. The actual automation is in the container yard, where Automated Guided Vehicles (AGVs) move containers to and from stacks served by automated stacking cranes (ASCs). Automation on this scale, however, requires building a new terminal or completely replacing an existing terminal, requiring heavy capital investment and a long development time.

Exhibit 85 compares claimed capacities and throughput per acre for benchmark terminals in each group. Few terminals post their capacities, so the available data are limited.

Exhibit 85: Terminal Productivity Benchmarks

Terminal	Acres	Published Capacity Annual TEU*	Max TEU/Acre	Sustainable @ 80%	Average
Conventional Terminals					
Oakland OICT (Est.)	290	2,105,789	6,581	5,264	6,061
Off-dock	30				
GCT Deltaport	210	1,800,000	8,571	6,857	
High Productivity					
VIG Portsmouth	291	2,000,000	6,873	5,498	7,112
TraPac Los Angeles	220	1,600,000	7,273	5,818	
Sydney Auto-strad	156	1,600,000	10,282	8,226	
Brisbane Auto-strad	99	1,100,000	11,134	8,907	
Complete Automation					
LBCT Long Beach	170	3,100,000	18,235	14,588	17,008
GCT Bayonne	70	1,700,000	24,286	19,429	

* OICT is actual TEU

Source: Industry publications and terminal websites

OICT currently has Oakland's highest throughput and throughput per acre. Multiple industry and study sources describe OICT as being near maximum capacity.

Exhibit 86: 2018 Port of Oakland Productivity

Oakland & OICT 2018 Average TEU/Acre	
Oakland 2018 TEU	2,537,400
Oakland Acres in Use	595
Oakland Avg TEU/Acre	**4,265**
OICT 2018 TEU	1,600,400
OICT Acres in Use	290
STE Off-dock Parking	30
OICT Avg TEU/Acre	**5,001**

Exhibit 86 shows OICT's 2018 volume was 1,600,400 TEU over 320 acres (290 terminal acres and 30 off-dock acres), a *current* average of 5,001 annual TEU/acre.

- Based on multiple opinions that OICT is operating near capacity, the consultant team assumed that the terminal is at 95% of a *sustainable capacity* of 5,264 TEU/acre.
- The industry rule of thumb is that a terminal's *sustainable throughput is 80% of its maximum capacity* (Exhibit 85), which yields a *maximum capacity of 6,581 TEU per acre* or 2.1 million annual TEU for the 320 acres in use.

As Exhibit 85 shows, this estimate puts OICT's productivity lower than GCT Deltaport but close to VIG Portsmouth and TraPac Los Angeles.

Exhibit 85 calculates that the average for conventional terminals is 6,061 TEU/acre, for high productivity terminals is 7,112 (17% higher), and for aggressive automation is 17,088 TEU/acre (181% higher than the conventional average). It should be noted that the claims for high throughputs at completely automated terminals have not yet been proven in practice.

Port of Oakland Container Terminals

Exhibit 87 provides a summary of the Port's acreage in terminals and major off-dock parcels. The locations are also shown in Exhibit 88.

Exhibit 87: Port of Oakland Terminals and Acreages

Terminal	Acres	2019 Acres in Use	Available Acres	Build-out Acres	Post-Electrification Acres
Ben Nutter	75	75	0	**98**	**96**
Berths 33-34	23		23		
OICT 55-56	120	120	0	**290**	**288**
OICT 57-59	170	170	0		
TraPac	123	123	0	**123**	**121**
Matson	75	75	0	**114**	**112**
Roundhouse	39		39		
OHT Berths 20-24	150		150	**150**	**148**
Howard*	50		50	**40**	**38**
Subtotal	**825**	**563**	**262**	**815**	**803**
Off-Dock	126	30	96	**0**	**0**
Total	**951**	**593**	**358**	**815**	**803**

* Assumes 10 acres will be used for Inner Harbor Turning Basin

Exhibit 88: Port of Oakland Map

The Port has three parcels of land contiguous with marine terminals and potentially usable as parts of those terminals.

The unused area at Berths 33–34, between the Ben E. Nutter and TraPac terminals, totals 23 acres. This is the only possible expansion space for the Nutter terminal, and as Exhibit 87 shows the consultant team has treated it as part of a full build-out for that facility. The area at “Berth 34” is not usable as a vessel berth due to the presence of BART’s Transbay Tube about 20’ below water level.

OICT is effectively fully built out, at 290 acres, sharing its eastern boundary with the Matson terminal. OICT is also currently using 30 acres of off-dock land for parking, operated by sister company Shippers’ Transport Express (STE). The full working area of OICT is therefore 320 acres at present. STE also operates an 11 acre facility at French Camp, which acts as a “reliever” for OICT. That facility, however, is well outside the Port area, and could be replaced by other space in the inland region.

The TraPac terminal has recently been rebuilt and expanded to 123 acres. It is adjacent to the vacant “Outer Harbor Terminal” (OHT, former Ports America) site. Because TraPac has recently been expanded and because the 150-acre OHT site is large enough for a separate terminal, this analysis limits TraPac to 123 acres.

The Matson terminal presently occupies 75 acres. The adjacent Roundhouse site of 39 acres could be used to extend Matson’s terminal to a total of 95 acres, although it does not provide additional berth length.

The Howard Terminal, presently used for ancillary support functions, covers 50 acres. There are no significant expansion options for Howard, and the Inner Harbor Turning Basin could reduce the available land to 40 acres.

The Berth 22–24 “Outer Harbor Terminal” (OHT) site is what remains of the former Ports America terminal after a portion was used to expand TraPac. The site covers 150 acres, and this analysis treats it as a separate terminal.

Current CARB emission goals call for zero emissions or near-zero emissions at marine terminals by 2030. With current and foreseeable technologies, achieving these goals requires electrification. Existing electrification technologies place two additional requirements on terminal land:

- Space for a battery exchange and servicing building. At LBCT in Long Beach, this function consumes about 1 acre.
- Additional electric service, potentially including a local substation. The consultant team has allowed an additional acre for this function.

The post-electrical acres in Exhibit 87 therefore reduce the available size of each terminal by 2 acres. Since automation effectively requires electrification, the capacity estimates below reduce the working acres of each terminal according to Exhibit 87 as automation is added.

The Port also has about 126 acres of undeveloped off-dock space, part of the former Oakland Army Depot. About 30 acres is currently being used by OICT and STE for supplementary parking of containers on chassis. All existing planning documents anticipated this land being used for ancillary support uses, rail infrastructure, or commercial development similar to the Centerpoint and Cool Port projects. This analysis therefore excludes this site from the terminal capacity estimates.

It should be noted that whether the Berth 33–34 site becomes part of the Nutter terminal or the TraPac terminal does not make a difference in the planning-level capacity estimates. Nor does it matter whether OHT becomes a separate terminal or part of TraPac. The only relevant size distinction is that automation strategies favor larger terminal sizes. While that factor may influence the sequence in which terminals are automated under some scenarios, the long-term potential capacity is a function of the total acres available.

Expansion Scenarios

Existing marine terminals typically expand incrementally to relieve congestion and accommodate trade growth. Marine terminal expansion is costly and time consuming. Ports and terminals therefore tend to expand existing facilities as needed rather than adding large increments of capacity that may not be utilized for several years.

New terminals, or complete replacements for existing terminals, may on the other hand build capacity for a more distant future. They may also be built in stages, with rising utilization of the first stage triggering construction of the next.

Oakland's terminal acreage has been almost completely built out, but as noted above, three significant expansion opportunities remain:

- 20 acres at Berths 33–34, which this analysis treats as expansion room for the Ben E. Nutter terminal.
- 39 acres at the Roundhouse property, which this analysis treats as expansion room for the Matson terminal.
- 150 acres at the Outer Harbor Terminal (OHT) site, which this analysis treats as an opportunity to repair and upgrade the former Ports America infrastructure, or to rebuild as a new terminal.

A review of Port of Oakland planning documents, former terminal configurations, industry literature, and practices at other ports suggests the following conceptual path for Port of Oakland terminal expansion and capacity increases.

Phase I: Low-Cost Horizontal Expansion on Available Terminal Acres

Horizontal expansion onto contiguous, available land is the quickest and least costly means of increasing capacity, and offers the greatest flexibility.

- The space at Berths 33–34 is paved and was part of a former container terminal configuration. Only temporary fencing and barriers separate this space from the Ben E. Nutter terminal, and that terminal already uses a portion under lease.
- The Roundhouse[vi] property is paved and has been used for truck parking and empty container storage. It is separated from the Matson terminal by fencing and temporary barriers, and Matson is already using a portion.
- The OHT site is more complex, as it includes multiple structures and has been used for a variety of trucking operations. It is paved, and includes multiple berths and cranes.
- The Howard Terminal was last used for container operations in 2014. It contains structures and four cranes.

vi The property is the site of the former Western Pacific Railroad roundhouse.

The Phase 1 expansion scenario would involve progressive reactivation of these sites and either incorporating them in expanded terminals (Berths 33–34 into Ben E. Nutter, the Roundhouse site into Matson) or operating them as separate terminals (OHT and Howard).

Exhibit 89 provides a capacity estimate for the 2018 configuration and for the Phase 1 horizontal expansion, including adjustments for electrification (reduction of 2 acres per terminal) Under the assumptions documented here, this expansion would raise total sustainable capacity from about 3.3 million annual TEU in 2018 to 4.3 million annual TEU when complete. *This estimate also assumes that all Oakland terminals would have the capability to equal OICT's estimated sustainable capacity of 5,264 annual TEU per acre under conventional operations.*

Exhibit 76: Scenario Capacity Estimates: 815 Acres

Estimated Sustainable Capacity at 815/803 Acres	Port Capacity Estimates						
	2018 Capacity Estimate	Phase 1: Low-Cost Horizontal Expansion on Available Terminal Acres	Phase II: 150 Acres High Productivty at OICT or OHT	Phase III: High Productivity at OICT & OHT	Phase IV: High Productivity at OICT, OHT, Ben Nutter	Phase V: High Productivity at OICT, OHT, Ben Nutter, TraPac	Phase VI: High Productivity at all Terminals
Total Terminal Acres	**825**	**815**	**813**	**811**	**809**	**807**	**803**
Terminal Acres in Conventional Use	593	815	663	371	271	146	0
Terminal Acres in High Productivity Use	0	0	148	436	532	653	791
Terminal Acres in Electrification Support	0	0	2	4	6	8	12
Total Off-dock Acres	**126**	**126**	**126**	**126**	**126**	**126**	**126**
Off-Dock Acres in Conventional Use	30	0	0	0	0	0	0
Available Off-Dock Acres	96	126	126	126	126	126	126
Total Port Acres	**855**	**815**	**813**	**811**	**809**	**807**	**803**
Total Acres in Conventional Use	623	815	663	371	271	146	0
Total Acres in High Productivity Use	0	0	148	436	532	653	791
Conventional Annual TEU/Acre (OICT 2018)	**5,264**	**5,264**	**5,264**	**5,264**	**5,264**	**5,264**	**5,264**
Conventional Capacity	3,279,767	4,290,546	3,490,346	1,953,120	1,426,672	768,613	-
High Productivity Annual TEU/Acre	**7,112**	**7,112**	**7,112**	**7,112**	**7,112**	**7,112**	**7,112**
High Productivity Capacity	-	-	1,052,614	3,100,945	3,783,722	4,644,306	5,625,797
Total Sustainable Capacity	**3,279,767**	**4,290,546**	**4,542,960**	**5,054,065**	**5,210,395**	**5,412,919**	**5,625,797**

Phase II: Enhanced Efficiency on 150 Acres at OICT or OHT

This Phase is representative of partial automation or other productivity improvements in response to trade growth. OICT has essentially no expansion room and is reportedly close to maximum capacity, and would be the most likely candidate for partial automation (150 acres) or other methods of significantly increasing throughput per acre.

An equivalent outcome would be shifting the 150-acre OHT terminal to high productivity, replacing 150 acres of conventional capacity there.

Exhibit 89 shows the estimated capacity increase using the 7,112 TEU/acre average for sustainable throughput at high productivity (Exhibit 85). This approach would increase capacity from 4.3 million TEU in Phase I to 4.5 million TEU in Phase II.

Phase III: Enhanced Efficiency at OICT and OHT

Phase III would extend high productivity operation to the remaining areas of OICT and OHT in response to trade growth. As noted above OICT is reportedly close to capacity, and automation would likely be easier in reactivating OHT than retrofitting TraPac or Ben E. Nutter. Matson and Howard are small relative to the usual suggested minimums for effective automation.

Phase III as outlined here and shown in Exhibit 89 would increase sustainable throughput capacity from 4.5 million to 5.1 million annual TEU.

Phase IV: Enhanced Efficiency at OICT, OHT, and Ben E. Nutter

Phase IV expansion would extend automation to the expanded 97-acre Ben E. Nutter terminal, raising the high productivity area to a total of 537 acres (Exhibit 89). The remaining 268 acres at TraPac, Matson, and Howard would remain under conventional operation.

This extension of high productivity operations would raise total capacity from 5.1 million to 5.2 million annual TEU.

Phase V: Enhanced Efficiency at OICT, OHT, Ben E. Mutter, and TraPac

The TraPac terminal might be the last to increase productivity as it was the most recently expanded and updated and likely has the most reserve capacity as of 2019.

This Phase would add TraPac's 123 acres to the high productivity total and raise Port capacity from 5.2 million to 5.4 million annual TEU.

Phase VI: Enhanced Efficiency at All Terminals

Extending high productivity capability to all terminals, including Matson and Howard, would raise sustainable port capacity from 5.4 million to 5.6 million annual TEU.

Expansion Progression

Exhibit 90 shows the estimated sustainable capacity in TEU in four scenarios: with Howard and Berths 20-21, without Howard, without Berths 20-21, and with neither Howard nor Berths 20-21. (Berths 20-21 are presently under consideration for dry bulk use.)

Exhibit 77: Estimated Sustained Capacity at Port of Oakland by Port Configuration Scenario

Estimated Sustainable Capacity at:	2018 Capacity Estimate	Phase 1: Low-Cost Horizontal Expansion on Available Terminal Acres	Phase II: 150 Acres High Productivty at OICT or OHT	Phase III: High Productivity at OICT & OHT	Phase IV: High Productivity at OICT, OHT, Ben Nutter	Phase V: High Productivity at OICT, OHT, Ben Nutter, TraPac	Phase VI: High Productivity at all Terminals
815/803 Acres	3,279,767	4,290,546	4,542,960	5,054,065	5,210,395	5,412,919	5,625,797
775/763 Acres w/o Howard	3,279,767	4,079,967	4,332,382	4,843,486	4,999,816	5,202,340	5,341,307
795/783 Acres w/o Berths 20-21	3,279,767	4,185,257	4,437,671	4,911,820	5,068,149	5,270,674	5,483,552
755/743 Acres w/o Howard or Berths 20-21	3,279,767	3,974,678	4,227,092	4,701,241	4,857,570	5,060,095	5,199,062

Expansion Beyond Phase VI

- Capacity increase beyond "high productivity" at all terminals could come from:
- More aggressive automation (e.g. ASCs and AGVs).
- Improved information flow and operational optimization to reduce container dwell times.
- Use of off-dock space for "relief" container storage capacity.
- Moving empty storage off-dock.

Capacity Comparisons

Based on the capacity estimates in the previous section, Exhibit 91 shows the progression of capacity increases needed to handle the forecast cargo growth. The various capacity phases are color-coded to match the Phase depicted in Exhibit 90. Cells that are shaded dark orange indicate years in which projected volume exceeds maximum capacity.

- At a total of 815 acres:
  - in the Moderate Case, a succession of capacity increases is required through Phase IV, providing capacity of 5.21 million TEU to accommodate 5.19 million TEU in 2050.
  - in the Slow Case, the volume reaches 3.86 million TEU requiring only Phase I expansion for a capacity of 4.29 million TEU.
  - in the Strong Case, the Port would have to reach the Phase VI capacity level (full efficiency upgrades) of 5.63 million TEU in 2041, and would have a capacity shortfall by 2042.
- At a total of 775 acres without Howard Terminal:
  - in the Moderate Case, a succession of capacity increases is required through Phase VI, providing capacity of 5.21 million TEU to accommodate 5.19 million TEU in 2050.
  - in the Slow Case, the volume reaches 3.86 million TEU requiring only Phase I expansion for a capacity of 4.08 million TEU.
  - in the Strong Case, the Port would have to reach the Phase VI capacity level (full efficiency upgrades) of 5.34 million TEU in 2040, and would have a capacity shortfall by 2041.
- At a total of 795 acres without Berths 20-21:
  - in the Moderate Case, a succession of capacity increases is required through Phase V, providing capacity of 5.27 million TEU to accommodate 5.19 million TEU in 2050.
  - in the Slow Case, the volume reaches 3.86 million TEU requiring only Phase I expansion for a capacity of 4.19 million TEU.
  - in the Strong Case, the Port would have to reach the Phase VI capacity level (full efficiency upgrades) of 5.48 million TEU in 2040, and would have a capacity shortfall by 2042.

- At a total of 755 acres without Howard Terminal or Berths 20-21:
    - in the Moderate Case, the Port would have to reach the Phase VI capacity level (full efficiency upgrades) of 5.20 million TEU in 2050, and would have a capacity shortfall by 2049. At this point the Port would have reached capacity, with essentially no room for additional growth.
    - in the Slow Case, the volume reaches 3.86 million TEU requiring only Phase I expansion for a capacity of 3.97 million TEU.
    - in the Strong Case, the Port would have to reach the Phase VI capacity level (full efficiency upgrades) of 5.20 million TEU in 2039, and would have a capacity shortfall by 2040.

Exhibit 78: TEU Forecast and Capacity

Millions of TEU	Comparison at 815/803 Acres						Comparison at 775/763 Acres w/o Howard						Comparison at 795/783 Acres w/o Berths 20-21						Comparison at 755/743 Acres w/o Howard or Berths 20-21					
	Moderate Growth	Available Capacity	Slow Growth	Available Capacity	Strong growth	Available Capacity	Moderate Growth	Available Capacity	Slow Growth	Available Capacity	Strong growth	Available Capacity	Moderate Growth	Available Capacity	Slow Growth	Available Capacity	Strong growth	Available Capacity	Moderate Growth	Available Capacity	Slow Growth	Available Capacity	Strong growth	Available Capacity
2018	2.55	3.28	2.55	3.28	2.55	3.28	2.55	3.28	2.55	3.28	2.55	3.28	2.55	3.28	2.55	3.28	2.55	3.28	2.55	3.28	2.55	3.28	2.55	3.28
2019	2.50	3.28	2.47	3.28	2.55	3.28	2.50	3.28	2.47	3.28	2.55	3.28	2.50	3.28	2.47	3.28	2.55	3.28	2.50	3.28	2.47	3.28	2.55	3.28
2020	2.50	3.28	2.40	3.28	2.64	3.28	2.50	3.28	2.40	3.28	2.64	3.28	2.50	3.28	2.40	3.28	2.64	3.28	2.50	3.28	2.40	3.28	2.64	3.28
2021	2.51	3.28	2.40	3.28	2.80	3.28	2.51	3.28	2.40	3.28	2.80	3.28	2.51	3.28	2.40	3.28	2.80	3.28	2.51	3.28	2.40	3.28	2.80	3.28
2022	2.63	3.28	2.50	3.28	3.03	3.28	2.63	3.28	2.50	3.28	3.03	3.28	2.63	3.28	2.50	3.28	3.03	3.28	2.63	3.28	2.50	3.28	3.03	3.28
2023	2.83	3.28	2.53	3.28	3.11	3.28	2.83	3.28	2.53	3.28	3.11	3.28	2.83	3.28	2.53	3.28	3.11	3.28	2.83	3.28	2.53	3.28	3.11	3.28
2024	2.98	3.28	2.56	3.28	3.18	3.28	2.98	3.28	2.56	3.28	3.18	3.28	2.98	3.28	2.56	3.28	3.18	3.28	2.98	3.28	2.56	3.28	3.18	3.28
2025	3.04	3.28	2.60	3.28	3.27	3.28	3.04	3.28	2.60	3.28	3.27	3.28	3.04	3.28	2.60	3.28	3.27	3.28	3.04	3.28	2.60	3.28	3.27	3.28
2026	3.11	3.28	2.65	3.28	3.37	4.29	3.11	3.28	2.65	3.28	3.37	4.08	3.11	3.28	2.65	3.28	3.37	4.19	3.11	3.28	2.65	3.28	3.37	3.97
2027	3.18	3.28	2.69	3.28	3.45	4.29	3.18	3.28	2.69	3.28	3.45	4.08	3.18	3.28	2.69	3.28	3.45	4.19	3.18	3.28	2.69	3.28	3.45	3.97
2028	3.23	3.28	2.72	3.28	3.53	4.29	3.23	3.28	2.72	3.28	3.53	4.08	3.23	3.28	2.72	3.28	3.53	4.19	3.23	3.28	2.72	3.28	3.53	3.97
2029	3.27	3.28	2.74	3.28	3.59	4.29	3.27	3.28	2.74	3.28	3.59	4.08	3.27	3.28	2.74	3.28	3.59	4.19	3.27	3.28	2.74	3.28	3.59	3.97
2030	3.31	4.29	2.77	3.28	3.72	4.29	3.31	4.08	2.77	3.28	3.72	4.08	3.31	4.19	2.77	3.28	3.72	4.19	3.31	3.97	2.77	3.28	3.72	3.97
2031	3.37	4.29	2.80	3.28	3.98	4.29	3.37	4.08	2.80	3.28	3.98	4.33	3.37	4.19	2.80	3.28	3.98	4.19	3.37	3.97	2.80	3.28	3.98	4.23
2032	3.42	4.29	2.83	3.28	4.19	4.29	3.42	4.08	2.83	3.28	4.19	4.33	3.42	4.19	2.83	3.28	4.19	4.44	3.42	3.97	2.83	3.28	4.19	4.23
2033	3.49	4.29	2.87	3.28	4.30	4.54	3.49	4.08	2.87	3.28	4.30	4.33	3.49	4.19	2.87	3.28	4.30	4.44	3.49	3.97	2.87	3.28	4.30	4.70
2034	3.57	4.29	2.92	3.28	4.42	4.54	3.57	4.08	2.92	3.28	4.42	4.84	3.57	4.19	2.92	3.28	4.42	4.44	3.57	3.97	2.92	3.28	4.42	4.70
2035	3.65	4.29	2.97	3.28	4.55	5.05	3.65	4.08	2.97	3.28	4.55	4.84	3.65	4.19	2.97	3.28	4.55	4.91	3.65	3.97	2.97	3.28	4.55	4.70
2036	3.74	4.29	3.02	3.28	4.69	5.05	3.74	4.08	3.02	3.28	4.69	4.84	3.74	4.19	3.02	3.28	4.69	4.91	3.74	3.97	3.02	3.28	4.69	4.70
2037	3.83	4.29	3.08	3.28	4.83	5.05	3.83	4.08	3.08	3.28	4.83	5.00	3.83	4.19	3.08	3.28	4.83	4.91	3.83	3.97	3.08	3.28	4.83	4.86
2038	3.93	4.29	3.14	3.28	4.98	5.05	3.93	4.08	3.14	3.28	4.98	5.20	3.93	4.19	3.14	3.28	4.98	5.07	3.93	3.97	3.14	3.28	4.98	5.06
2039	4.03	4.29	3.20	3.28	5.14	5.21	4.03	4.08	3.20	3.28	5.14	5.20	4.03	4.19	3.20	3.28	5.14	5.27	4.03	4.23	3.20	3.28	5.14	5.20
2040	4.12	4.29	3.26	3.28	5.29	5.41	4.12	4.33	3.26	3.28	5.29	5.34	4.12	4.19	3.26	3.28	5.29	5.48	4.12	4.23	3.26	3.28	5.29	5.20
2041	4.22	4.29	3.32	4.29	5.45	5.63	4.22	4.33	3.32	4.08	5.45	5.34	4.22	4.44	3.32	4.19	5.45	5.48	4.22	4.23	3.32	3.97	5.45	5.20
2042	4.33	4.54	3.38	4.29	5.61	5.63	4.33	4.33	3.38	4.08	5.61	5.34	4.33	4.44	3.38	4.19	5.61	5.48	4.33	4.70	3.38	3.97	5.61	5.20
2043	4.42	4.54	3.43	4.29	5.77	5.63	4.42	4.84	3.43	4.08	5.77	5.34	4.42	4.91	3.43	4.19	5.77	5.48	4.42	4.70	3.43	3.97	5.77	5.20
2044	4.53	4.54	3.49	4.29	5.94	5.63	4.53	4.84	3.49	4.08	5.94	5.34	4.53	4.91	3.49	4.19	5.94	5.48	4.53	4.70	3.49	3.97	5.94	5.20
2045	4.63	5.05	3.55	4.29	6.11	5.63	4.63	4.84	3.55	4.08	6.11	5.34	4.63	4.91	3.55	4.19	6.11	5.48	4.63	4.70	3.55	3.97	6.11	5.20
2046	4.73	5.05	3.61	4.29	6.28	5.63	4.73	4.84	3.61	4.08	6.28	5.34	4.73	4.91	3.61	4.19	6.28	5.48	4.73	4.86	3.61	3.97	6.28	5.20
2047	4.84	5.05	3.67	4.29	6.46	5.63	4.84	5.00	3.67	4.08	6.46	5.34	4.84	4.91	3.67	4.19	6.46	5.48	4.84	5.06	3.67	3.97	6.46	5.20
2048	4.95	5.05	3.73	4.29	6.65	5.63	4.95	5.00	3.73	4.08	6.65	5.34	4.95	5.07	3.73	4.19	6.65	5.48	4.95	5.06	3.73	3.97	6.65	5.20
2049	5.07	5.21	3.80	4.29	6.84	5.63	5.07	5.20	3.80	4.08	6.84	5.34	5.07	5.27	3.80	4.19	6.84	5.48	5.07	5.20	3.80	3.97	6.84	5.20
2050	5.19	5.21	3.86	4.29	7.04	5.63	5.19	5.20	3.86	4.08	7.04	5.34	5.19	5.27	3.86	4.19	7.04	5.48	5.19	5.20	3.86	3.97	7.04	5.20
CAGR	**2.2%**	**1.5%**	**1.3%**	**0.9%**	**3.2%**	**1.8%**	**2.2%**	**1.5%**	**1.3%**	**0.7%**	**3.2%**	**1.6%**	**2.2%**	**1.5%**	**1.3%**	**0.8%**	**3.2%**	**1.7%**	**2.2%**	**1.5%**	**1.3%**	**0.6%**	**3.2%**	**1.5%**

Port of Oakland Container Terminal and Capacity Findings

Terminal Capacity

The forecasts and capacity scenarios indicate that the Port of Oakland has sufficient estimated capacity at present to accommodate cargo growth through 2024-2040, depending on the cargo growth pattern (with the Moderate Growth scenario requiring additional capacity starting in 2033).

Starting in the 2024-2034 period cargo growth will trigger a need for additional capacity. That additional capacity is likely to be obtained first by horizontal expansion on available land, and then through investment in automation or equivalent productivity improvements. It should be noted that many of the benefits obtained by semi-automated and "fully" automated terminals are generated by improved terminal configurations, equipment, and information systems, not by automation per se.

- Under the Moderate Case the Port is likely to have some reserve capacity by 2050, but only with significant productivity increases.
- If long-term cargo growth is suppressed by continuing adverse trade conditions and persistently sluggish economic growth, the Port will likely have adequate capacity for the forecast period.
- More rapid long-term growth in the Strong Case forecast will lead to capacity shortfalls by 2041.

It is not certain that the productivity investments envisioned in high productivity scenarios would be economically justified and financially feasible. Recent adverse financial trends in the container shipping industry have handicapped terminal owners in attempting to recover the cost of added capacity from their carrier clients.

The scenario of progressive capacity increases envisioned in this analysis relies on high productivity operations to enable upgrades of existing facilities while they remain largely operational. While more aggressive and costly automation approaches may be able to yield even higher throughputs, those approaches require enough near-term excess capacity to take terminals out of service for complete rebuilding. In the Southern California case, additional space was available during the recession years and fill was used to expand the terminal area – an approach that will probably not be available in the Bay Area.

The tables below summarize these comparisons. Exhibit 92 shows that the Port of Oakland would be at or near capacity by 2050 under the moderate growth forecast and with estimated maximum terminal capacity under high productivity assumptions. If both Howard and Berths 20-21 were withdrawn from container cargo use, the port would be at full capacity by 2050. The slow growth forecast would leave Oakland at 69%-74% of capacity by 2050, while the strong growth forecast would exceed the port's estimated maximum capacity by 25% to 35%.

Exhibit 92: Container Cargo Growth Versus Terminal Capacity

Estimated Sustainable Capacity at:	Phase VI: High Productivity at all Terminals	2050 Moderate Growth TEU and Maximum Capacity Utilization		2050 Slow Growth TEU and Maximum Capacity Utilization		2050 Strong Growth TEU and Maximum Capacity Utilization	
815/803 Acres	5,625,797	5,187,588	**92%**	3,862,435	69%	7,038,560	125%
775/763 Acres w/o Howard	5,341,307	5,187,588	**97%**	3,862,435	72%	7,038,560	132%
795/783 Acres w/o Berths 20-21	5,483,552	5,187,588	**95%**	3,862,435	70%	7,038,560	128%
755/743 Acres w/o Howard or Berths 20-21	5,199,062	5,187,588	**100%**	3,862,435	74%	7,038,560	135%

To facilitate comparisons between cargo types, Exhibit 93 shows terminal acres needed and available under the maximum productivity assumption.

Exhibit 93: Container Cargo Growth and Acreage Requirements

Container Terminal Acres	2050 Acres Available	Moderate Growth		Slow Growth		Strong Growth	
		Required	Reserve	Required	Reserve	Required	Reserve
All Terminals	803	729	74	543	260	990	(187)
Without Howard	743	729	14	543	200	990	(247)
Without Berths 20-21	773	729	44	543	230	990	(217)
Without Howard or Berths 20-21	723	729	(6)	543	180	990	(267)

Port of Oakland Berth Capacity

Existing Oakland Container Berths

Exhibit 88 shows the existing (2019) terminals at the Port of Oakland, and the location of berths and container cranes. There are basically two berthing areas:

- The Outer Harbor - berths 20-37 (TraPac and Ben E. Nutter Terminals)
- The Inner Harbor - berths 55-68 (OICT, Matson, and Howard Terminals)

Exhibit 94 shows the berth lengths.

Exhibit 94: Port of Oakland Berth Lengths

As Exhibit 95 indicates, not all of the existing berths have container cranes, although both Berths 20-21 and Berth 38 had cranes at one time. "Berth 34" is not usable for ordinary vessel operation due to the underwater presence of the BART Transbay Tube. Berths 35 (Ben E. Nutter Terminal) and 67 (Howard Terminal) have "dolphins," extensions of the wharf face with mooring line attachments but not cargo handling capabilities. These dolphins allow the full use of the berth length for cargo handling.

Exhibit 95: Berth Dimensions

Terminal Berth Dimensions (feet)

Berth	Depth	Length	Dolphin	Total	Nominal Berths
20-21**	42	1,355			2
22-26	50	4,250		4,250	5
30-33	50	2,850		2,850	3
34*	37				0
35-37	50	2,157	100	2,257	2
38**	50	850			1
55-59	50	6,000		6,000	5
60-63	42	2,743		2,743	2
67-68	42	1,946	70	2,016	2
Total		**22,151**	**170**	**20,116**	**22**

* Limited by BART Tube

** No container cranes

Vessel berthing requirements are determined by vessel length and the requirement for mooring lines (Exhibit 96). Mooring lines from adjacent vessel can overlap, but common practice is to maintain spacing between the vessels roughly equal to their beam.

Exhibit 96: Vessel and Mooring Lines

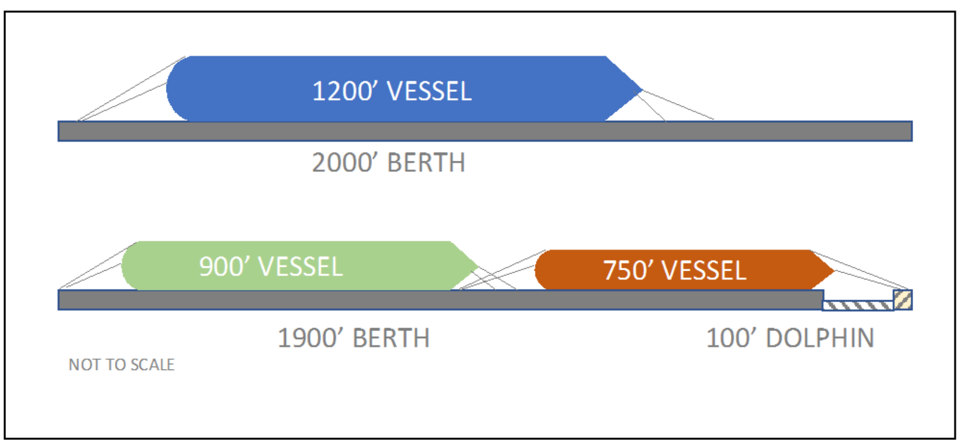
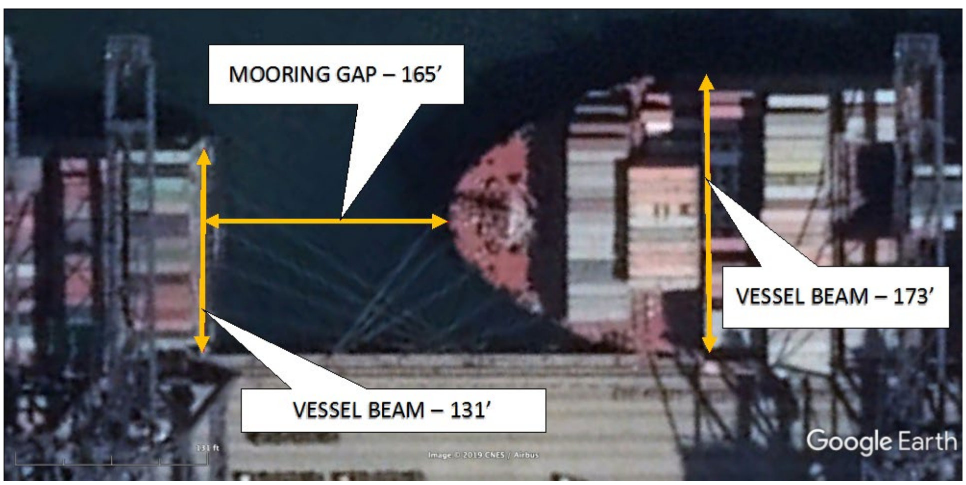


Exhibit 97 and Exhibit 98 provide examples of this practice. For purposes of this berthing analysis, the study team has allowed 150 feet beyond the vessel length for multiple vessels at the same berth expanse.

Exhibit 97: Vessel Mooring Line Span

Exhibit 98: Example of Vessel Mooring Gap



Existing Vessel Services

As of early 2019, Oakland is served by 28 container vessel services, with 29 weekly calls because one service calls semi-weekly (Exhibit 99). As Exhibit 99 shows, most vessel calls are alliance services but there are still individual carriers calls as well as the domestic services of Matson and Pasha.

Exhibit 99: Early 2019 Oakland Container Services

Terminal	Operator	Service	Frequency	Schedule Call Day	2019 Vessel Example	2019 Vessel Size TEU
Matson	Matson	Hawaii 2	Weekly	Mon	Kaimana Hila	3,600
Matson	Matson	Hawaii 1	Weekly	Wed	Daniel Inouye	3,600
Nutter	Ocean Alliance	CPS/CC5/AAC2/HBB	Weekly	Sat	NAVARINO	8,530
Nutter	Ocean Alliance	HTW/AAS3/GEX	Weekly	Sun	EVER SMART	7,024
Nutter	Ocean Alliance	TPS/Jade Express/AAS4/SC	Weekly	Wed	THALASSA ELPIDA	13,800
OICT	2M Alliance	TP8/Orient/PS4/UPAS1	Weekly	Fri	MAERSK ALGOL	9,580
OICT	2M Alliance	TP2/Jaguar/PS3/UPAS 2	Weekly	Tue	MAERSK ELBA	13,100
OICT	ANL	PSW1/PANZ-PSW/WAS/AC	Weekly	Sat	ANL WARRNAMBOOL	4,563
OICT	APL	EX1	Weekly	Fri	PRESIDENT WILSON	5,780
OICT	Hamburg Sud	WAMS/WCCA2/AZTEC1/W	Weekly	Fri	CAP PALLISER	1,841
OICT	Hamburg Sud	SSEA/Polynesia	Biweekly	Thu	Polynesia	1,304
OICT	Hapag-Lloyd	MPS/MCPS/MPS	Semi-weekly	Sun/Wed	Kobe Express	4,612
OICT	Hyundai	PS2/TP7/Lotus	Weekly	Fri	Hyundai Long Beach	6,350
OICT	MSC	California Express	Weekly	Wed	MSC Siliva	9,400
OICT	Ocean Alliance	Pearl River Express/SC1/PF	Weekly	Fri	CMA-CGM T Jefferson	14,414
OICT	Ocean Alliance	Columbus JAX/PE1/SEA2/F	Weekly	Mon	CMA-CGM Chennai	10,100
OICT	Ocean Alliance	CEN/BOHAI/CC2/CEN/PCN	Weekly	Sun	CSCL South China Sea	10,036
OICT	Pasha	CHX	Weekly	Wed	HORIZON PACIFIC	2,325
OICT	THE Alliance	PS6	Weekly	Sun	NYK ALTAIR	9,582
OICT	THE Alliance	AL5 WB/California Bridge/I	Weekly	Sun	NYK ROMULUS	4,888
OICT	THE Alliance	FP1	Weekly	Tue	Hamburg Bridge	8,212
OICT	COSCO/PIL/Wan	AC5	Weekly	Sat	Kota Panjang	11,900
OICT	THE Alliance	PS5	Weekly	Wed	YM UNICORN	8,636
TraPac	THE Alliance	PS4	Weekly	Fri	YM Maturity	6,572
TraPac	THE Alliance	PS7	Weekly	Mon	MOL BRILLIANCE	10,000
TraPac	THE Alliance	PS3	Weekly	Mon	NYK Athena	6,492
TraPac	THE Alliance	PS2/JPSW/PS2	Weekly	Tue	Brussels Bridge	4,432
TraPac	THE Alliance	EC1 WB	Weekly	Wed	MOL MATRIX	6,724

There services are complex, and carriers and alliances periodically change vessel rotations and service names, therefore it is difficult to make year-to-year comparisons. Exhibit 99 provides examples of vessels recently used in the Oakland services. Because many services operate with a mix of vessels and changes can occur at any time, the vessel specifications should be taken as indicative rather than definitive.

Exhibit 100 shows the berth occupancy implied by the schedules in Exhibit 99 and typical or estimated dwell times for the various vessel sizes. [Subject to Port and terminal verification]

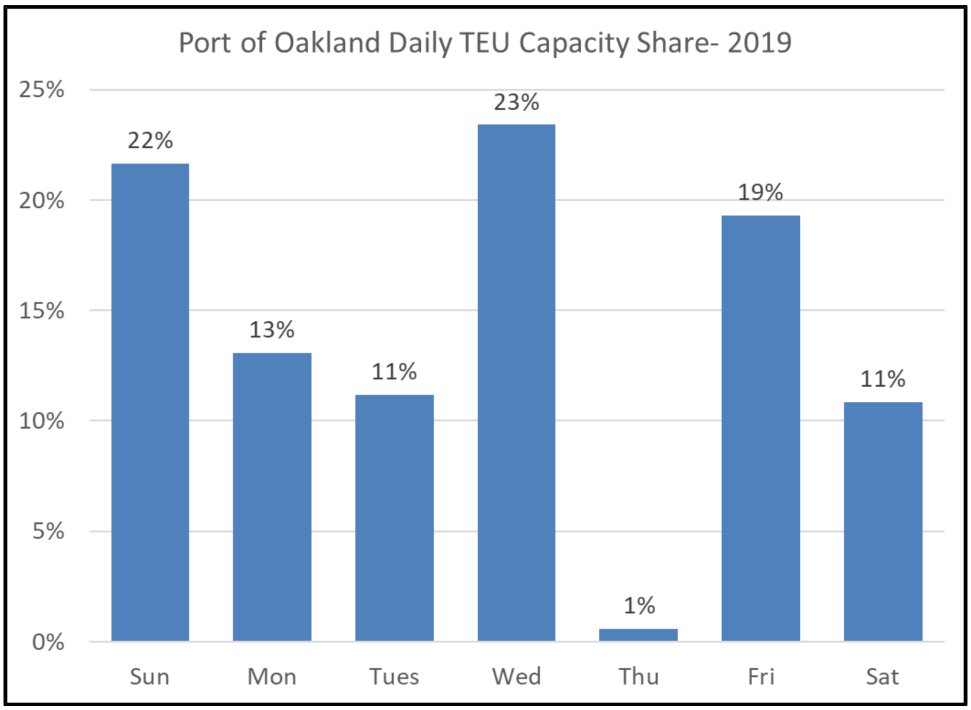
Exhibit 100: 2019 Estimated Berth Occupancy

Day of Week	Sunday			Monday			Tuesday			Wednesday			Thursday			Friday			Saturday		
Shift	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
OICT		AC5		Columbus JAX/PE1/SEA2/PE1/SEA						PS5						Pearl River Express/SC1/PR				AC5	
OICT	CEN/BOHAI/CC2/CEN/PCN1/CEN/						TP2/Jaguar/PS3/UP			CHX			SSEA/Polynes			WAMS/WCC			PSW1/PANZ-		
OICT	PS6						FP1			California Exp						TP8/Orient/PS4/UP					
OICT	MPS/MCPS/N									MPS/MCPS/N						PS2/TP7/Lotus					
OICT	AL5 WB/Calif															EX1					
TraPac				PS7						EC1 WB						PS4					
TraPac				PS3			PS2/JPSW/PS2														
Ben E. Nutter										TPS/Jade Express/A											
Ben E. Nutter	HTW/AAS3/GEX																				
Ben E. Nutter	CPS																		CPS/CC5/AAC2/HBB		
Matson				Hawaii 2						Hawaii 1											

On this basis, OICT, with five (nominal) berths, appears to be fully occupied Mondays and Fridays. TraPac has four (nominal) berths, two of which are occupied Monday-Tuesday. Ben E. Nutter Terminal has two berths, and would appear to have overlapping occupancy on Sundays. The Matson terminal has two berths, only one of which appears to be occupied at a time. Based on AIS data, however, some Matson vessels spend extended time in port. As Exhibit 100 implies and Exhibit 101 documents, Sunday, Wednesday, and Friday are the heavy vessel arrival days at Oakland.

Exhibit 100 also illustrates the need for "slack" in berth capacity to deal with late vessel arrivals or delays in terminal handling. For example, if the TP2 or FP1 services arrive late at OICT on Tuesday, they may be occupying a berth needed for the five vessels arriving Wednesday. As with other aspects of port operations, berth utilization of 75-80% may be considered a practical maximum, with higher utilization risking frequent disruption.

Exhibit 101: Daily Oakland Capacity Arrival Shares



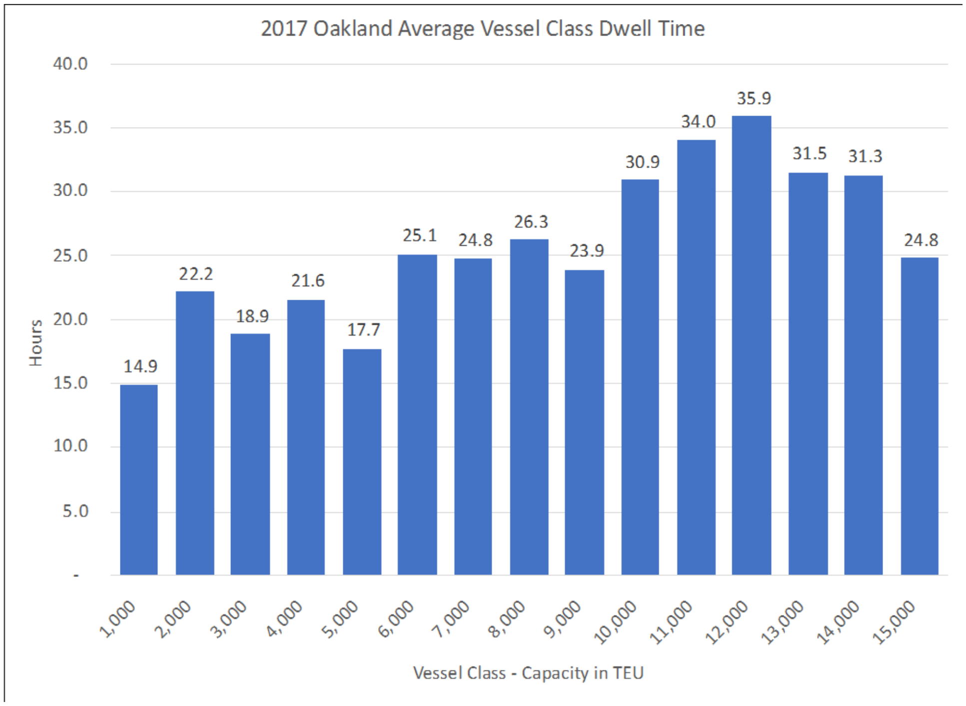
As both Exhibit 100 and Exhibit 101 imply, vessel arrivals and berth utilization are uneven. This unevenness is driven by:

- Sailing times from ports before or after Oakland in the service rotations.
- Market timing preferences of ocean carriers and their customers.
- The commercial relationship between ocean carriers and marine terminal operators.

While berth and terminal congestion *might* encourage some leveling across days and terminals in the long run, the pattern remains uneven at most ports after more than four decades of container shipping.

Vessels at berth take up both space and time. As Exhibit 102 shows, larger vessels typically, but not inevitably, stay longer at berth to handle the greater cargo volumes they usually carry. Containerships of up to 9,000 TEU typically stay in port for up to one full day, allowing two shifts (e.g. one day shift and one evening shift) to work the vessel if required. Vessels of 10,000 TEU and above typically spend 30-36 hours in port, allowing for a third shift (e.g. a day shift, an evening shift, and a second day shift) to work the vessel.

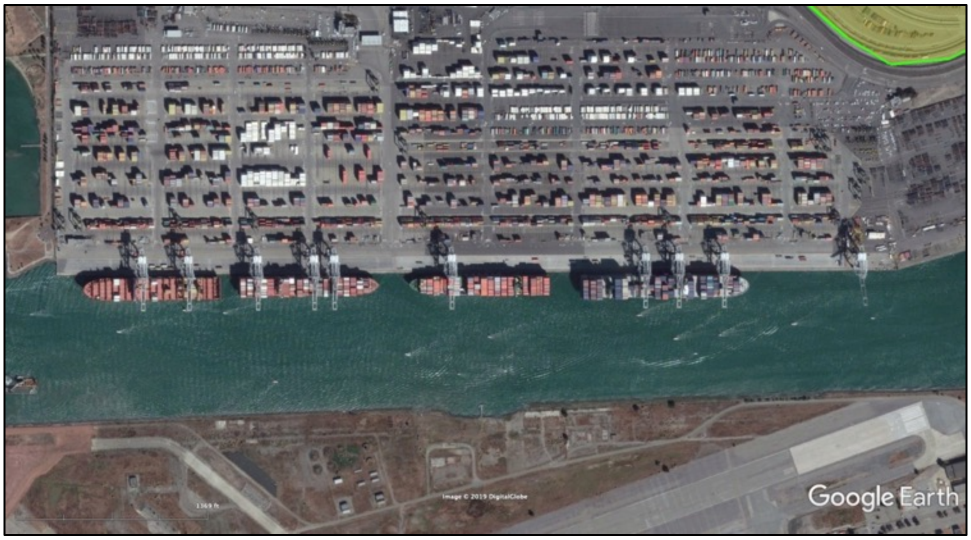
Exhibit 102: 2017 Vessel Class Dwell Times



The dwell time needed to handle a vessel and its import and export containers depends in part on the number of cranes assigned to handle the ship. Most vessels are worked with 2-4 cranes as required, while up to six may be used on the very largest ships. Industry participants indicate that terminals typically assign enough cranes to each vessel to meet the schedule. Expectations for the number of cranes available for a given service may be set in discussion between terminal operators and carriers, and may even be specified in contractual agreements. The aerial photograph in Exhibit 103, for example, shows nine cranes deployed across four vessels at OICT. The largest vessel, with three cranes, is a 1200 ft ship.

The use of additional cranes to speed up vessel handling is limited by the supply of cranes (which can be adjusted to some extent in the long run), the spacing needed between cranes, and the ocean carrier's willingness to incur additional costs. The common practice appears to be assigning additional cranes as needed to keep larger vessels on schedule rather than allowing dwell time to rise with cargo volume. Only for the very largest vessel and call volumes (e.g. mega-ships calling Los Angeles or Long Beach) have scheduled port calls been increased to a third day.

Exhibit 103: Crane Use at OICT



2050 Vessel Call Scenarios

In principle there are two ways in which vessel calls can change to accommodate cargo growth:

- Increased vessel sizes within existing services and schedules, or
- New services with additional vessel calls.

The study team developed a vessel call and berth occupancy scenario for each of these alternatives. In practice, the future will probably see a mix of strategies that cannot be predicted with any confidence. In both scenarios, vessel call expectations through 2035 are based on a November 2018 analysis prepared for the Port of Oakland by Mercator Associates. That analysis took service details and expected ocean carrier and alliance strategies into account, and predicted a progression of vessel size increases. Beyond 2035, the study team extrapolated vessel calls and sizes based on projected trade growth and increased vessel sizes.

Exhibit 104 shows the scenario developed for increased vessels sizes under the three growth scenarios. The Mercator analysis did not cover all of the existing Oakland services, so those that were not covered were extended through 2035 at existing or slightly increased growth rates. Some services have already increased vessel size beyond what Mercator predicted for 2020, as indicted in the table.

Exhibit 90: 2050 Scenarios for Increased Vessel Size

Terminal	Service	2019 Vessel Size TEU	Mercator 2018 Forecast*				Moderate			Slow			Strong		
			Mercator/ Tioga 2020	Mercator 2025	Mercator 2030	Mercator/ Tioga 2035	Tioga 2040	Tioga 2045**	Tioga 2050**	Tioga 2040	Tioga 2045	Tioga 2050	Tioga 2040	Tioga 2045	Tioga 2050
Matson	Hawaii 2	3,600	3,600	3,600	4,000	4,003	4,128	4,257	4,391	4,084	4,166	4,250	4,382	4,797	5,251
Matson	Hawaii 1	3,600	3,600	3,600	4,000	4,003	4,128	4,257	4,391	4,084	4,166	4,250	4,382	4,797	5,251
Nutter	CPS/CC5/AAC2/HBB	8,530	11,500	11,500	12,000	12,000	13,198	14,464	15,852	12,888	13,841	14,865	14,090	16,527	19,386
Nutter	HTW/AAS3/GEX	7,024	8,500	12,000	14,000	14,000	15,398	16,875	18,494	15,036	16,148	17,342	16,438	19,282	22,616
Nutter	TPS/Jade Express/AAS4/SC8	13,800	13,800	14,000	14,000	18,000	19,797	21,697	23,778	19,331	20,761	22,297	21,135	24,791	29,078
OICT	TP8/Orient/PS4/UPAS1	9,580	13,250	15,000	15,000	22,000	24,197	26,518	29,062	23,627	25,375	27,252	25,832	30,300	35,540
OICT	TP2/Jaguar/PS3/UPAS 2	13,100	13,700	13,700	16,000	16,000	17,598	19,286	21,136	17,183	18,454	19,820	18,787	22,036	25,847
OICT	PSW1/PANZ-PSW/WAS/AOS/Oceania	4,563	4,563	10,000	14,500	6,769	7,445	8,159	8,942	7,269	7,807	8,385	7,948	9,322	10,935
OICT	EX1	5,780	7,000	8,000	9,000	10,000	10,999	12,054	13,210	10,740	11,534	12,387	11,742	13,773	16,155
OICT	WAMS/WCCA2/AZTEC1/WC2	1,841	1,841	1,841	1,841	2,731	3,004	3,292	3,608	2,933	3,150	3,383	3,207	3,761	4,412
OICT	SSEA/Polynesia	1,304	1,304	1,304	1,304	1,934	2,128	2,332	2,555	2,077	2,231	2,396	2,271	2,664	3,125
OICT	MPS/MCPS/MPS	4,612	4,612	4,612	4,612	6,841	7,525	8,247	9,038	7,348	7,891	8,475	8,033	9,422	11,052
OICT	PS2/TP7/Lotus	6,350	8,500	8,500	11,000	11,000	12,098	13,259	14,531	11,814	12,687	13,626	12,916	15,150	17,770
OICT	California Express	9,400	9,400	9,400	9,400	13,944	15,336	16,808	18,420	14,975	16,083	17,273	16,373	19,205	22,526
OICT	Pearl River Express/SC1/PRX/AAS2/PCS	14,414	14,414	16,800	17,700	20,900	22,987	25,192	27,609	22,446	24,106	25,889	24,540	28,785	33,763
OICT	Columbus JAX/PE1/SEA2/PE1/SEAP-PS\	10,100	10,100	11,000	14,000	17,000	18,698	20,491	22,457	18,257	19,608	21,058	19,961	23,413	27,463
OICT	CEN/BOHAI/CC2/CEN/PCN1/CEN/AC3	10,036	13,500	14,500	19,000	19,000	20,897	22,902	25,099	20,405	21,915	23,536	22,309	26,168	30,694
OICT	CHX	2,325	2,325	2,325	2,325	2,585	2,666	2,749	2,836	2,637	2,690	2,745	2,830	3,098	3,391
OICT	PS6	9,582	9,582	9,582	12,000	15,000	16,498	18,081	19,815	16,110	17,301	18,581	17,613	20,659	24,232
OICT	AL5 WB/California Bridge/ECX	4,888	4,888	4,888	4,888	7,251	7,975	8,740	9,578	7,787	8,363	8,982	8,514	9,986	11,714
OICT	FP1	8,212	8,212	8,212	8,212	12,182	13,398	14,684	16,092	13,083	14,051	15,090	14,304	16,777	19,679
OICT	AC5	11,900	11,900			17,653	19,415	21,278	23,319	18,958	20,361	21,867	20,727	24,312	28,517
OICT	PS5	8,636	8,750	10,000	10,000	10,000	10,999	12,054	13,210	10,740	11,534	12,387	11,742	13,773	16,155
TraPac	PS4	6,572	6,500	8,200	10,000	10,000	10,999	12,054	13,210	10,740	11,534	12,387	11,742	13,773	16,155
TraPac	PS7	10,000	10,000	10,000	13,000	15,000	16,498	18,081	19,815	16,110	17,301	18,581	17,613	20,659	24,232
TraPac	PS3	6,492	6,600	9,100	10,000	13,000	14,298	15,670	17,173	13,962	14,994	16,103	15,264	17,904	21,001
TraPac	PS2/JPSW/PS2	4,432	4,500	5,500	6,500	7,500	8,249	9,040	9,908	8,055	8,651	9,290	8,806	10,329	12,116
TraPac	EC1 WB	6,724	6,724	6,724	6,724	9,974	10,970	12,023	13,176	10,712	11,505	12,356	11,712	13,737	16,113

* Data entries in blue indicate vessel sizes that have already increasd past Mercator estimates or were estimated by Tioga

Relying only on vessel size increase to accommodate trade growth would require some services to use vessels of nearly 36,000 TEU by 2050 in the string growth case.

The largest vessels built to date are between 21,000 and 22,000 TEU, as shown in Exhibit 105. As the data reveal, the largest vessels have overall lengths of 400 meters (1,312 feet), beams of about 59 meters (193 feet), and design drafts of 16.0 to 16.5 meters (52.5 to 54.1 feet). These vessels would require about 1,462 feet of berth when moored adjacent to others (about 1,1612 if moored separately). Sailing drafts are typically limited to about 90% of the maximum design draft. With 4 feet of underkeel clearance, as required by San Francisco Bay pilots, these vessels would require up to 51-53 feet of draft, about Oakland's current maximum. In practice, if these vessels call first at Los Angeles-Long Beach and discharge most of their import cargo, they would not use this full draft while calling at Oakland.

Exhibit 105: Largest Container Vessels as of Early 2019

	OOCL Hong Kong	COSCO Shipping Universe	CMA CGM Antoine de St Exupery	Madrid Maersk	Ever Golden	MOL Truth
TEU Capy	21,413	21,237	20,954	20,568	20,150	20,182
Length (m)	400	400	400	399	400	400
Beam (m)	58.8	58.6	59.0	58.8	58.8	58.5
Design Draft (m)	16.0	16.0	16.0	16.5	14.5	16.0
Length (ft)	1,312	1,312	1,312	1,309	1,312	1,312
Beam (ft)	193	192	194	193	193	192
Design Draft (ft)	52.5	52.5	52.5	54.1	47.6	52.5
Avg. Max Sailing Draft (ft)	47.2	47.2	47.2	48.7	42.8	47.2
Underkeel Clearance (ft)	4.0	4.0	4.0	4.0	4.0	4.0
Draft Required (ft)	**51.2**	**51.2**	**51.2**	**52.7**	**46.8**	**51.2**
Length (ft)	1,312	1,312	1,312	1,309	1,312	1,312
Mooring Allowance	150	150	150	150	150	150
Berth Required	**1,462**	**1,462**	**1,462**	**1,459**	**1,462**	**1,462**

As of early 2019, there are no orders for vessels beyond 22,000 TEU. There have been proposed conceptual designs for vessels up to 32,000 TEU and speculation on what vessels of up to 50,000 TEU would be like. There are doubts, however, whether vessels of over 36,000 TEU are either technically or economically feasible. Recent analyses indicate that vessel sizes over 20,000 TEU have diminishing returns to scale. It is fair to point out, however, that all previous estimates of the largest feasible vessel size have been exceeded in practice.

The Bay Area is limited by Oakland's channel and berth depth (currently a nominal 50 feet at most berths), and by the air draft (vertical clearance) under the bridges. The vessels shown in Exhibit 105 have already reached the maximum draft and air draft, so without relaxing those constraints future vessels must be longer and wider to increase capacity further.

Exhibit 106 presents typical examples of the vessel classes calling at Oakland. The largest vessels currently calling at Oakland are 1200 feet long and require 1350 feet of berth length (1500 feet if moored separately). These vessels correspond to the 1200-foot vessels shown in Exhibit 97 and Exhibit 103. As Exhibit 102 indicates, the longest dwell times for these vessels are around 36 hours.

Exhibit 106: 2019 Vessel Classes Calling Oakland

Class	1000	2000	3000	4000	5000	6000	7000
Vessel Example	Polynesia	CAP PALLISER	CAP CAPRICORN	KOTA EKSPRES	NYK ROMULUS	Hyundai Long Beach	EVER SMART
TEU Capacity	1304	1841	2824	3600	4,888	6,350	7,024
Length (ft)	529	611	748	854	964	961	984
Design Draft (ft)	32	37	41	33	44	46	47
Avg. Max Sailing Draft (ft)	29.2	33.4	36.9	30.1	39.9	41.3	41.9
Underkeel Clearance (ft)	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Draft Required (ft)	33.2	37.4	40.9	34.1	43.9	45.3	45.9
LOA	529	611	748	854	964	961	984
Mooring Allowance	150	150	150	150	150	150	150
Berth Required (ft)	679	761	898	1,004	1,114	1,111	1,134

Class	8000	9000	10000	11000	12000	13000	14000
Vessel Example	OOCL LONDON	GERNER MAERSK	MOL BRILLIANCE	CAPE KORTIA	MSC BERYL	MAERSK ELBA	CMA-CGM T Jefferson
TEU Capacity	8063	9038	10000	11010	12,400	13,100	14,414
Length (ft)	1,102	1,092	1,105	1,082	1,200	1202	1200
Design Draft (ft)	46	48	49	52	51	51	52
Avg. Max Sailing Draft (ft)	41.3	42.8	44.3	47.2	45.8	45.8	47.2
Underkeel Clearance (ft)	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Draft Required (ft)	45.3	46.8	48.3	51.2	49.8	49.8	51.2
LOA	1,102	1,092	1,105	1,082	1,200	1,202	1,200
Mooring Allowance	150	150	150	150	150	150	150
Berth Required (ft)	1,252	1,242	1,255	1,232	1,350	1,352	1,350

Exhibit 107 provides comparable data on larger vessel classes in use elsewhere (primarily in the Asia-Europe trades) but not yet calling at Oakland or on the U.S. West Coast.

Exhibit 107: Larger Vessel Classes in Use

Class	15000	16000	17000	18000	19000	20000	21000
Vessel Example	Ebba Maersk	CMA CGM JULES VERNE	APL SINGAPURA	CMA CGM BENJAMIN FRANKLIN	CSCL Globe	Ever Golden	OOCL Hong Kong
TEU Capacity	14770	16022	17292	17859	19,100	20,150	21,413
Length (ft)	1,304	1,299	1,305	1,309	1,311	1312	1312
Design Draft (ft)	51	52	52	52	52	48	52
Avg. Max Sailing Draft (ft)	45.8	47.2	47.2	47.2	47.2	42.8	47.2
Underkeel Clearance (ft)	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Draft Required (ft)	49.8	51.2	51.2	51.2	51.2	46.8	51.2
Length (ft)	1,304	1,299	1,305	1,309	1,311	1,312	1,312
Mooring Allowance	150	150	150	150	150	150	150
Berth Required (ft)	1,454	1,449	1,455	1,459	1,461	1,461	1,462

Exhibit 108 provides conceptual dimensions of a vessel up to 40,000 TEU by increasing maximum length and beam in increments, estimated dwell hours, and increase over the current maximum. These dimensions are strictly conceptual, and the estimated dwell hours shown allow for use of four full day and evening shifts (40 hours) to handle vessels of up to 25,000 TEU. Larger vessels require an additional 16 hours to use a fifth shift (including a night shift during which the vessel is idle) and 24 hours to use six full shifts for the very largest sizes.

Exhibit 108: Possible Dimensions of Vessel up to 40,000 TEU

Metric	Current Max	Near-term Max	% Increase	Mid-term Max	% Increase	Long-term Max (?)	% Increase	Ultimate Max (?)	% Increase
LOA (m)	400	400	0%	450	13%	500	25%	500	25%
Beam (m)	60	70	17%	80	33%	80	33%	90	50%
"Area" (m^2)	24,000	28,000	17%	36,000	50%	40,000	67%	45,000	88%
TEU	21,413	24,982	17%	32,120	50%	35,688	67%	40,149	88%
Dwell Hours	36	40	11%	56	56%	56	56%	64	78%

These conceptual dimensions were used to generate the equally conceptual vessel specifications in Exhibit 109. Note that the vessel beam is not listed; the analysis implicitly assumes that cranes will be built and deployed with sufficient outreach.

Exhibit 109: Conceptual Vessel Class Specifications to 40,000 TEU

Class	22000	23000	24000	25000	26000	27000	28000
Vessel Example	Estimated	Estimated	Estimated	Estimated	Estimated	Estimated	Estimated
TEU Capacity	22000	23000	24000	25000	26000	27000	28000
Length (ft)	1,312	1,312	1,312	1,312	1,476	1476	1476
Design Draft (ft)	54.1	54.1	54.1	54.1	54.1	54.1	54.1
Avg. Max Sailing Draft (ft)	48.7	48.7	48.7	48.7	48.7	48.7	48.7
Underkeel Clearance (ft)	4.0	4.0	4.0	4.0	4.0	32.4	40.6
Draft Required (ft)	52.7	52.7	52.7	52.7	52.7	4.0	4.0
Length (ft)	1,312	1,312	1,312	1,312	1,476	1,476	1,476
Mooring Allowance	150	150	150	150	150	150	150
Berth Required (ft)	1,462	1,462	1,462	1,462	1,626	1,626	1,626

Class	29000	30000	31000	32000	33000	34000	35000
Vessel Example	Estimated	Estimated	Estimated	Estimated	Estimated	Estimated	Estimated
TEU Capacity	29000	30000	31000	32000	33000	34000	35000
Length (ft)	1,476	1,476	1,476	1,476	1,640	1640	1640
Design Draft (ft)	54.1	54.1	54.1	54.1	54.1	54.1	54.1
Avg. Max Sailing Draft (ft)	48.7	48.7	48.7	48.7	48.7	48.7	48.7
Underkeel Clearance (ft)	4.0	4.0	4.0	4.0	4.0	48.7	48.7
Draft Required (ft)	52.7	52.7	52.7	52.7	52.7	4.0	18.2
Length (ft)	1,476	1,476	1,476	1,476	1,640	1,640	1,640
Mooring Allowance	150	150	150	150	150	150	150
Berth Required (ft)	1,626	1,626	1,626	1,626	1,790	1,790	1,790

Class	36000	37000	38000	39000	40000
Vessel Example	Estimated	Estimated	Estimated	Estimated	Estimated
TEU Capacity	36000	37000	38000	39000	40000
Length (ft)	1,640	1,640	1,640	1,640	1,640
Design Draft (ft)	54.1	54.1	54.1	54.1	54.1
Avg. Max Sailing Draft (ft)	48.7	48.7	48.7	48.7	48.7
Underkeel Clearance (ft)	4.0	4.0	4.0	4.0	4.0
Draft Required (ft)	52.7	52.7	52.7	52.7	52.7
Length (ft)	1,640	1,640	1,640	1,640	1,640
Mooring Allowance	150	150	150	150	150
Berth Required (ft)	1,790	1,790	1,790	1,790	1,790

Moderate Growth Berth Occupancy

Application of longer vessel dwell times to the existing berth occupancy shown in Exhibit 100 yields overlapping vessel calls at OICT and Ben E. Nutter. Those vessel calls must then be handled at other berths and terminals, particularly at an extended TraPac terminal (assumed for this purpose to include berths 30-33 and 22-26). Exhibit 110 shows selected vessel services moved from OICT and Ben E. Nutter to TraPac, Howard, and Berths 20-21. Exhibit 110 considers both hours and lengths, and shifts vessel calls as required to keep the daily vessel total within berth length limits.

Exhibit 110: 2050 Estimated Berth Occupancy - By Dwell Hours and Berths - Moderate Growth

Day of Week		Sunday			Monday			Tuesday			Wednesday			Thursday			Friday			Saturday		
Shift		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
OICT		CEN/BOHAI/CC2/CEN/PCN1/CEN/AC3				40					AC5				36		EX1				36	
		1,626	1,626	1,626	1,626	1,626					1,626	1,626	1,626	1,626	1,626		1,455	1,455	1,455	1,455	1,455	
OICT		PS6				40		TP2/Jaguar/PS3/UPAS 2				40		SSEA/Polynesia			WAMS/WCCA2/AZT		24			
		1,462	1,462	1,462	1,462	1,462		1,626	1,626	1,626	1,626	1,626		1,004	1,004	1,004	1,114	1,114	1,114			
OICT	6000'	AL5 WB/California Bridge/ECX				36		FP1				36										
		1,350	1,350	1,350	1,350	1,350		1,462	1,462	1,462	1,462	1,462										
OICT																	PS2/TP7/Lotus				36	
																	1,459	1,459	1,459	1,459	1,459	
OICT		TP8/Orier	56		Columbus JAX/PE1/SEA2/PE1/SEAP-PSV				40								TP8/Orient/PS4/UPAS1					56
		1,790	1,790		1,626	1,626	1,626	1,626	1,626								1,790	1,790	1,790	1,790	1,790	1,790
TraPac					PS7				40		EC1 WB				36		PS4					
					1,462	1,462	1,462	1,462	1,462		1,455	1,455	1,455	1,455	1,455		1,455	1,455	1,455	1,455	1,455	
TraPac					PS3				36													
					1,462	1,462	1,462	1,462	1,462													
TraPac	4250'	HTW/AAS3/GEX				40		PS2/JPSW/PS2				36										
		1,462	1,462	1,462	1,462	1,462		1,350	1,350	1,350	1,350	1,350										
TraPac		Pearl Riv	56								PS5				36		Pearl River Express/SC1/PRX/AAS2/PCS1/AC6/CP3					56
		1,790	1,790								1,455	1,455	1,455	1,455	1,455		1,790	1,790	1,790	1,790	1,790	1,790
TraPac		PSW1/PA	36								CHX		24							PSW1/PANZ-PSW/V		36
		1,232	1,232								1,004	1,004	1,004							1,232	1,232	1,232
TraPac	2850'	CPS/CC5	36								California Express				36					CPS/CC5/AAC2/HBB		36
		1,462	1,462								1,462	1,462	1,462	1,462	1,462					1,462	1,462	1,462
Ben E. Nutter								TPS/Jade Express/AAS4/SC8				40										
								1,626	1,626	1,626	1,626	1,626										
Ben E. Nutter	2257'	MPS/MCPS/MPS				36								MPS/MCPS/MPS				36				
		1,350	1,350	1,350	1,350	1,350								1,350	1,350	1,350	1,350	1,350				
Ben E. Nutter	850'																					
Matson	2743'				Hawaii 2		24				Hawaii 1		24									
					1,111	1,111	1,111				1,111	1,111	1,111									
Howard	981'																					
Vacant 20-21	1355'																					

Howard Terminal and Berths 20-21 could serve as relievers in Exhibit 110, handling vessel calls per week that could not be accommodated at other terminals; under the Moderate Growth scenario this was not necessary. Exhibit 111 shows the implied berth occupancy rates by terminals and shift.

Exhibit 111: Estimated 2050 Berth Occupancy by Terminal - Moderate Growth

Day of Week	Length	Sunday			Monday			Tuesday			Wednesday			Thursday			Friday			Saturday		
Shift		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Vacant 20-21*	1,355	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TraPac 22-26	4,250	77%	77%	34%	103%	103%	69%	101%	101%	32%	100%	100%	68%	68%	68%	0%	76%	76%	76%	76%	76%	42%
		3,252	3,252	1,462	4,386	4,386	2,924	4,274	4,274	1,350	4,261	4,261	2,910	2,910	2,910	-	3,245	3,245	3,245	3,245	3,245	1,790
TraPac 30-33	2,850	95%	95%	0%	0%	0%	0%	0%	0%	0%	87%	87%	87%	51%	51%	0%	0%	0%	0%	95%	95%	95%
		2,694	2,694	-	-	-	-	-	-	-	2,466	2,466	2,466	1,462	1,462	-	-	-	-	2,694	2,694	2,694
BEN 35-37	2,257	60%	60%	60%	60%	60%	0%	72%	72%	72%	72%	72%	0%	60%	60%	60%	60%	60%	0%	0%	0%	0%
		1,350	1,350	1,350	1,350	1,350	-	1,626	1,626	1,626	1,626	1,626	-	1,350	1,350	1,350	1,350	1,350	-	-	-	-
BEN 38	850	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
OICT 55-59	6,000	104%	104%	74%	101%	101%	27%	79%	79%	51%	79%	79%	27%	44%	44%	17%	97%	97%	97%	78%	78%	30%
		6,228	6,228	4,438	6,064	6,064	1,626	4,714	4,714	3,088	4,714	4,714	1,626	2,630	2,630	1,004	5,819	5,819	5,819	4,704	4,704	1,790
Matson 60-63	2,743	0%	0%	0%	41%	41%	41%	0%	0%	0%	41%	41%	41%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		-	-	-	1,111	1,111	1,111	-	-	-	1,111	1,111	1,111	-	-	-	-	-	-	-	-	-
Howard 67-68**	981	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

*Proposed for dry bulk
** Reduced by 965' for turning basin expansion and a further 70' for loss of dolphin

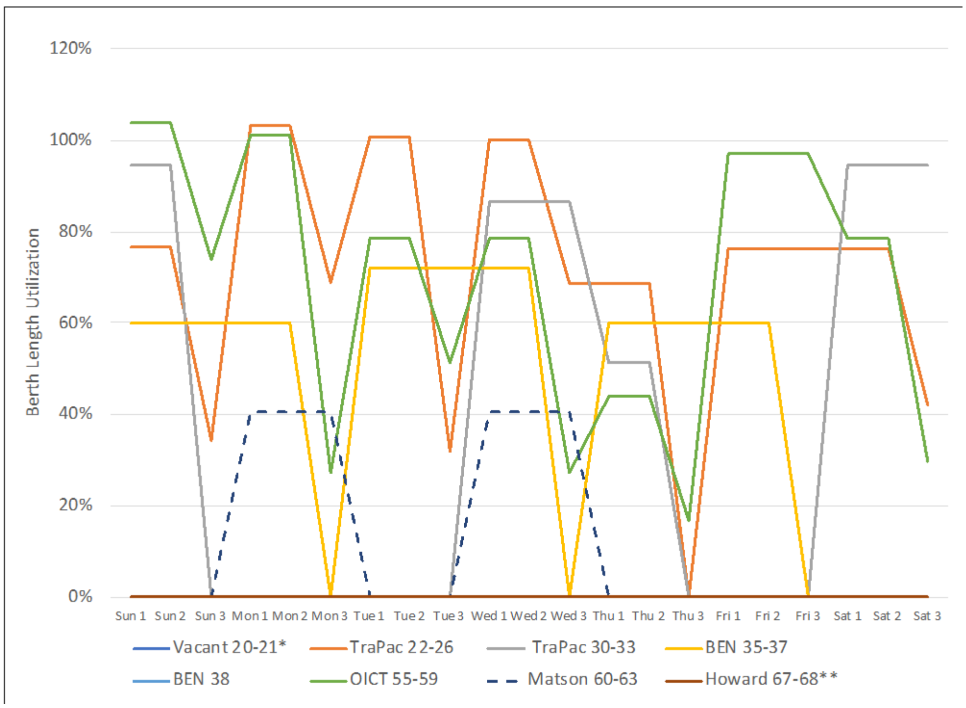
In Exhibit 111:

- Berths 20-21 do not currently have cranes, and at a total of 1,355 feet could not handle many of the vessels assumed to be calling in 2050 under this scenario.
- Berth 38, at 850 feet and without cranes, could not accommodate any of the vessel strings assumed to be calling in 2050. The economic feasibility of equipping Berth 38 with cranes is questionable.
- The Howard Terminal berth length has been reduced by an estimated 300 feet to allow for the expansion of the Inner Harbor Turning Basin.

- No non-Matson services are shifted to the Matson terminal (Berths 60-63). Matson is not a member of any of the existing alliances, and as a matter of company policy and strategy has not ordinarily shared terminals with other operators. The consultant team's analysis assumed this practice will continue, although institutional preferences can easily change over a 31-year time horizon.
- The analysis does not impose a strict cut-off at 100% utilization with the understanding that terminals may space vessels closer or take other measures to make maximum use of available berth length.

These estimated utilization rates are charted in Exhibit 112. The chart shows that, without using the Matson terminal, Howard terminal, or Berths 20-21 for other services, the Port's berths would be busiest on the Monday and Wednesday day shifts with a combined berth occupancy at OICT, Ben E. Nutter, and TraPac of over 80%.

Exhibit 112: 2050 Vessel Size Increase Scenario Berth Occupancy - Moderate Growth



This analysis suggests that an assumption of vessel size growth to accommodate the moderate growth cargo forecast would result in tight berth constraints by 2050. A more definitive analysis would require development of a sophisticated berth allocation and optimization model, and testing of multiple scenarios.

Slow Growth Berth Occupancy

Exhibit 113 and Exhibit 114 provide comparable berth utilization perspectives for the Slow Growth scenario. Again, this slower growth does not apparently require use of Howard or Berths 20–21 for container operations by 2050.

Exhibit 113: 2050 Estimated Berth Occupancy - By Dwell Hours and Berths - Slow Growth

2050 Estimated Berth Occupancy - By Dwell Hours and Berth Length - Slow Growth																						
Day of Week			Sunday			Monday			Tuesday			Wednesday			Thursday			Friday			Saturday	
Shift		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
OICT		CEN/BOHAI/CC2/CEN/PCN1/CEN/AC3				36											EX1				36	
		1,462	1,462	1,462	1,462	1,462											1,350	1,350	1,350	1,350	1,350	
OICT		PS6				36		TP2/Jaguar/PS3/UPAS 2				36		SSEA/Polynesia		24	WAMS/WCCA2/AZ1		24			
		1,461	1,461	1,461	1,461	1,461		1,462	1,462	1,462	1,462	1,462		898	898	898	1,004	1,004	1,004			
OICT	6000'	AL5 WB/California Bridge/ECX			24			FP1				36										
		1,242	1,242	1,242	1,242			1,449	1,449	1,449	1,449	1,449										
OICT		MPS/MCPS/MPS		24							MPS/MCPS/MPS		24				PS2/TP7/Lotus				36	
		1,242	1,242	1,242							1,242	1,242	1,242				1,459	1,459	1,459	1,459	1,459	
OICT					Columbus JAX/PE1/SEA2/PE1/SEAP PSV				36								TP8/Oricnl/PS4/UPAS1				1626	
					1,462	1,462	1,462	1,462	1,462								1,626	1,626	1,626	1,626	1,626	
TraPac					PS7				36		EC1 WB				36		PS4				36	
					1,461	1,461	1,461	1,461	1,461		1,350	1,350	1,350	1,350	1,350		1,350	1,350	1,350	1,350	1,350	
TraPac					PS3				36													
					1,455	1,455	1,455	1,455	1,455													
TraPac	4250'	HTW/AAS3/GEX				36		PS2/IPSW/PS2				36										
		1,459	1,459	1,459	1,459	1,459		1,255	1,255	1,255	1,255	1,255										
TraPac											PS5				36		Pearl River Express/SC1/PRX/AAS2/PCS1				40	
											1,455	1,455	1,455	1,455	1,455		1,626	1,626	1,626	1,626	1,626	
TraPac											CHX		24							PSW1/PANZ-PSW/V		24
											898	898	898							1,242	1,242	1,242
TraPac	2850'	CPS/CC5	36								California Express				36					CPS/CC5/AAC2/HBB		36
		1,454	1,454								1,455	1,455	1,455	1,455	1,455					1,454	1,454	1,454
Ben E. Nutter								TPS/Jade Express/AAS4/SC8				36										
								1,462	1,462	1,462	1,462	1,462										
Ben E. Nutter	2257'	AC5	36																	AC5		36
		1,626	1,626																	1,462	1,462	1,462
Ben E. Nutter	850'																					
Matson	2743'				Hawaii 2		24				Hawaii 1		24									
					1,114	1,114	1,114				1,114	1,114	1,114									
Howard	981'																					
Vacant 20-21	1355'																					

As Exhibit 114 indicates, however, berth utilization becomes very tight at TraPac and OICT on several days including Sunday through Wednesday.

Exhibit 114: Estimated 2050 Berth Occupancy by Terminal - Slow Growth

Day of Week	Length		Sunday			Monday			Tuesday			Wednesday			Thursday			Friday			Saturday	
Shift		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Vacant 20-21*	1,355	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TraPac 22-26	4,250	34%	34%	34%	103%	103%	69%	98%	98%	30%	96%	96%	66%	66%	66%	0%	70%	70%	70%	70%	70%	0%
		1,459	1,459	1,459	4,375	4,375	2,916	4,171	4,171	1,255	4,061	4,061	2,806	2,806	2,806	-	2,976	2,976	2,976	2,976	2,976	-
TraPac 30-33	2,850	51%	51%	0%	0%	0%	0%	0%	0%	0%	83%	83%	83%	51%	51%	0%	0%	0%	0%	95%	95%	95%
		1,454	1,454	-	-	-	-	-	-	-	2,353	2,353	2,353	1,455	1,455	-	-	-	-	2,697	2,697	2,697
BEN 35-37	2,257	72%	72%	0%	0%	0%	0%	65%	65%	65%	65%	65%	0%	0%	0%	0%	0%	0%	0%	65%	65%	65%
		1,626	1,626	-	-	-	-	1,462	1,462	1,462	1,462	1,462	-	-	-	-	-	-	-	1,462	1,462	1,462
BEN 38	850	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
OICT 55-59	6,000	90%	90%	90%	94%	73%	24%	73%	73%	49%	69%	69%	21%	15%	15%	15%	91%	91%	91%	74%	74%	0%
		5,407	5,407	5,407	5,627	4,385	1,462	4,373	4,373	2,911	4,153	4,153	1,242	898	898	898	5,440	5,440	5,440	4,436	4,436	-
Matson 60-63	2,743	0%	0%	0%	41%	41%	41%	0%	0%	0%	41%	41%	41%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		-	-	-	1,114	1,114	1,114	-	-	-	1,114	1,114	1,114	-	-	-	-	-	-	-	-	-
Howard 67-68**	981	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

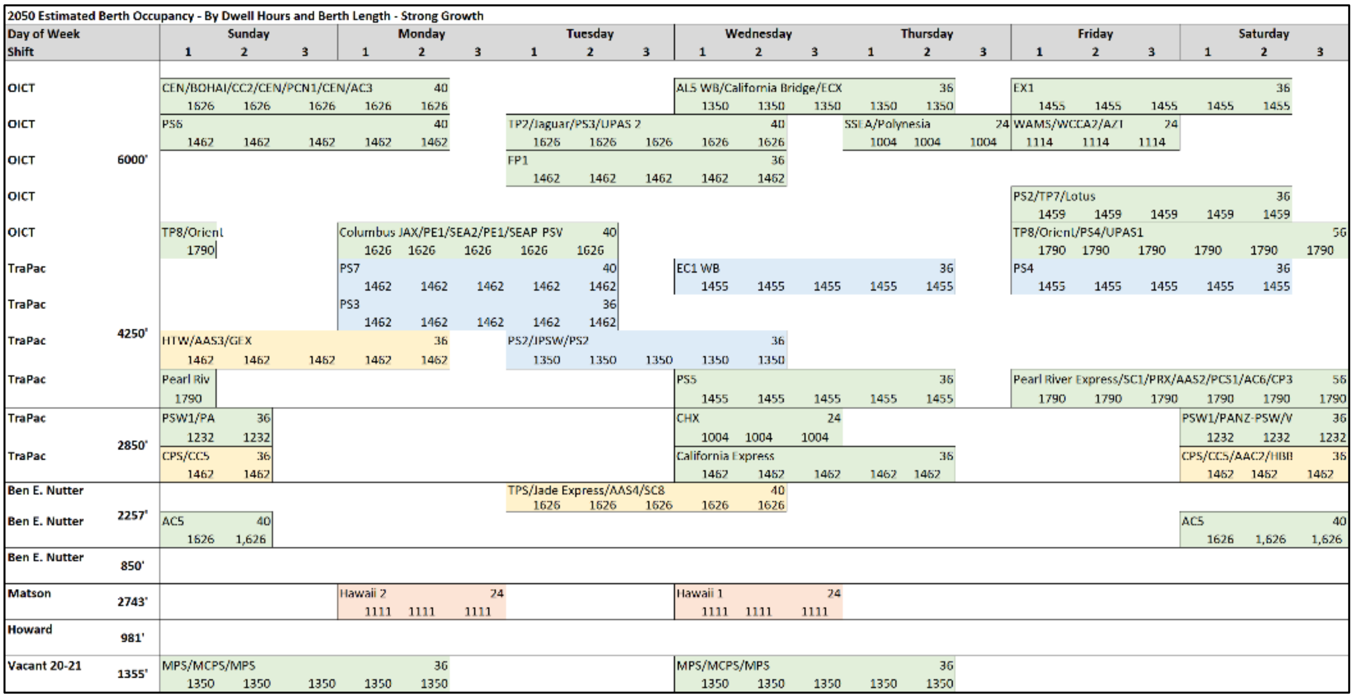
*Proposed for dry bulk

** Reduced by 965' for turning basin expansion and a further 70' for loss of dolphin

Strong Growth Berth Occupancy

As expected, the strong cargo growth scenario implies larger vessels, longer dwell times, and higher berth utilization. Exhibit 115 shows the use of Berths 20–21 as a reliever for the other terminals. Howard Terminal would also be able to fulfill this role should Berths 20-21 not be available for container operations.

Exhibit 115: 2050 Estimated Berth Occupancy - By Dwell Hours and Berths - Strong Growth



The larger vessel sizes can reduce five "nominal" berths to four working berths, as shown for OICT in Exhibit 115. Although in one sense OICT appears to have a vessel position available every day of the week, none of the other vessel services can fit. As Exhibit 116 reveals, OICT's berth length utilization would vary between 39% and 97%, illustrating the structural unevenness of vessel services.

Exhibit 116: Estimated 2050 Berth Occupancy by Terminal - Strong Growth

Day of Week		Sunday			Monday			Tuesday			Wednesday			Thursday			Friday			Saturday		
Shift		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Vacant 20-21*	1,355	100% 1350	100% 1350	100% 1350	100% 1350	100% 1350	0% 0	0% 0	0% 0	0% 0	100% 1350	100% 1350	100% 1350	100% 1350	100% 1350	0% 0	0% 0	0% 0	0% 0	0% 0	0% 0	0% 0
TraPac 22-26	4,250	77% 3,252	34% 1,462	34% 1,462	103% 4,386	103% 4,386	69% 2,924	101% 4,274	101% 4,274	32% 1,350	100% 4,261	100% 4,261	68% 2,910	68% 2,910	68% 2,910	0% -	76% 3,245	76% 3,245	76% 3,245	76% 3,245	76% 3,245	42% 1,790
TraPac 30-33	2,850	95% 2,694	95% 2,694	0% -	0% -	0% -	0% -	0% -	0% -	0% -	87% 2,466	87% 2,466	87% 2,466	51% 1,462	51% 1,462	0% -	0% -	0% -	0% -	95% 2,694	95% 2,694	95% 2,694
BEN 35-37	2,257	72% 1,626	72% 1,626	0% -	0% -	0% -	0% -	72% 1,626	72% 1,626	72% 1,626	72% 1,626	72% 1,626	0% -	0% -	0% -	0% -	0% -	0% -	0% -	72% 1,626	72% 1,626	72% 1,626
BEN 38	850	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
OICT 55-59	6,000	81% 4,878	51% 3,088	51% 3,088	79% 4,714	79% 4,714	27% 1,626	79% 4,714	79% 4,714	51% 3,088	74% 4,438	74% 4,438	23% 1,350	39% 2,354	39% 2,354	17% 1,004	97% 5,819	97% 5,819	97% 5,819	78% 4,704	78% 4,704	30% 1,790
Matson 60-63	2,743	0% -	0% -	0% -	41% 1,111	41% 1,111	41% 1,111	0% -	0% -	0% -	41% 1,111	41% 1,111	41% 1,111	0% -	0% -	0% -	0% -	0% -	0% -	0% -	0% -	0% -
Howard 67-68**	981	0% -	0% -	0% -	0% -	0% -	0% -	0% -	0% -	0% -	0% -	0% -	0% -	0% -	0% -	0% -	0% -	0% -	0% -	0% -	0% -	0% -

*Proposed for dry bulk
** Reduced by 965' for turning basin expansion and a further 70' for loss of dolphin

Limiting Vessel Sizes to 25,000 TEU Capacity

It is difficult to envision what the true dimensions of the largest containerships might be in 30 years' time. The unconstrained approach to vessel size utilized above results in a service that features containerships with a nominal capacity of 36,000 TEU and an estimated length of 1,640 feet. The infrastructure requirements necessary to support such a vessel would be significant on both the water side (including dredging) and land side (including taller and/or wider cranes). As such, the consultant team performed a second berth occupancy analysis based on the assumption that vessel sizes would reach a practical limitation of 25,000 TEU on the Asia-North America route.

The 25,000 cap was applied to vessels, after which point the overflow capacity requirements were spread to other vessels within the same alliance or an additional service made up of two smaller vessels. In the first case the consultant team restricted capacity overflow to services on a similar trade lane. Overflowing the excess volume on to different services infers a shift in trade route requirements but the port rotations offered by the shipping liners in 30 years will likely substantially differ to those currently used regardless. When a service was split, the assumption was that shipping lines would attempt to utilize an efficient combination of vessels to maximize the economies of scale that accompany the use of larger vessels.

The 25,000 TEU vessel restriction results in calls being capped at five shifts, although some services require additional shifts due to upscaling. Additional services required to handle the overflow cargo also result in additional berth utilization.

The Moderate Growth Scenario with vessels limited to a nominal capacity of 25,000 TEU would require one service to shift some capacity to a second service within the same alliance and the introduction of one additional service. Exhibit 117 shows that Howard Terminal and vacant Berths 20–21 are still not required as a reliever for the other terminals.

Exhibit 117: 2050 Estimated Berth Occupancy - Moderate Growth with Capped Vessel Size

2050 Estimated Berth Occupancy - By Dwell Hours and Berth Length - Moderate Growth with Vessels Capped at 25,000 TEU

Day of Week		Sunday			Monday			Tuesday			Wednesday			Thursday			Friday			Saturday		
Shift		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
OICT		CEN/BOHAI/CC2/CEN/PCN1/CEN/AC3				40					ALS WB/California Bridge/ECX				36		EX1				36	
		1,462	1,462	1,462	1,462	1,462					1,255	1,255	1,255	1,255	1,255		1,350	1,350	1,350	1,350	1,350	
OICT		PS6				36		TP2/Jaguar/PS3/UPAS 2				40		SSEA/Polynesia		24	WAMS/WCCA2/AZT		24			
		1,462	1,462	1,462	1,462	1,462		1,462	1,462	1,462	1,462	1,462		898	898	898	898	898	898			
OICT	6000'							FP1				36										
								1,455	1,455	1,455	1,455	1,455										
OICT																	PS2/TP7/Lotus				36	
																	1,454	1,454	1,454	1,454	1,454	
OICT							Columbus JAX/PE1/SEA2/PE1/SEAP PSW				36						TP8/Oricnl/PS4/UPAS1				40	
							1,462	1,462	1,462	1,462	1,462						1,462	1,462	1,462	1,462	1,462	
TraPac					PS7				36		EC1 WB				36		PS4				36	
					1,462	1,462	1,462	1,462	1,462		1,350	1,350	1,350	1,350	1,350		1,350	1,350	1,350	1,350	1,350	
TraPac																	PS3				36	
																	1,455	1,455	1,455	1,455	1,455	
TraPac	4250'	HTW/AAS3/GEX				36					PS2/JPSW/PS2				36							
		1,461	1,461	1,461	1,461	1,461					1,255	1,255	1,255	1,255	1,255							
TraPac					TPS/Jade Express/AAS4/SC8				36		PS5				36		Pearl River Express/SC1/PRX/AAS2/PCS1				36	
					1,462	1,462	1,462	1,462	1,462		1,350	1,350	1,350	1,350	1,350		1,350	1,350	1,350	1,350	1,350	
TraPac		PSW1/PA	24		OVERFLOW OCEAN ALLIANCE Pearl Rive				36		CHX		24							PSW1/PANZ-PSW/V		24
		1,242	1,242		1,350	1,350	1,350	1,350	1,350		898	898	898							1,242	1,242	1,242
TraPac	2850'	CPS/CC5	36								California Express				36					CPS/CC5/AAC2/HBB		36
		1,449	1,449								1,461	1,461	1,461	1,461	1,461					1,449	1,449	1,449
Ben E. Nutter																	AC5				36	
																	1,462	1,462	1,462	1,462	1,462	
Ben E. Nutter	2257'	MPS/MCPS/MPS				24					MPS/MCPS/MPS				24							
		1,242	1,242	1,242	1,242	1,242					1,242	1,242	1,242	1,242	1,242							
Ben E. Nutter	850'																					
Matson	2743'				Hawaii 2		24				Hawaii 1		24									
					1,114	1,114	1,114				1,114	1,114	1,114									
Howard	981'																					
Vacant 20-21	1355'																					

Exhibit 118 shows the implied berth occupancy rates by terminals and shift.

Exhibit 118: Estimated 2050 Berth Occupancy by Terminal - Moderate Growth with Capped Vessel Size

Day of Week		Sunday			Monday			Tuesday			Wednesday		
Shift		1	2	3	1	2	3	1	2	3	1	2	3
Vacant 20-21*	1,355	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		0	0	0	0	0	0	0	0	0	0	0	0
TraPac 22-26	4,250	34%	34%	34%	103%	103%	69%	69%	69%	0%	93%	93%	93%
		1,461	1,461	1,461	4,385	4,385	2,924	2,924	2,924	-	3,956	3,956	3,956
TraPac 30-33	2,850	94%	94%	0%	47%	47%	47%	47%	47%	0%	83%	83%	83%
		2,691	2,691	-	1,350	1,350	1,350	1,350	1,350	-	2,359	2,359	2,359
BEN 35-37	2,257	55%	55%	55%	55%	55%	0%	0%	0%	0%	55%	55%	55%
		1,242	1,242	1,242	1,242	1,242	-	-	-	-	1,242	1,242	1,242
BEN 38	850	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
OICT 55-59	6,000	49%	49%	49%	49%	49%	24%	73%	73%	73%	94%	70%	21%
		2,924	2,924	2,924	2,924	2,924	1,462	4,379	4,379	4,379	5,634	4,172	1,255
Matson 60-63	2,743	0%	0%	0%	41%	41%	41%	0%	0%	0%	41%	41%	41%
		-	-	-	1,114	1,114	1,114	-	-	-	1,114	1,114	1,114
Howard 67-68**	981	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		-	-	-	-	-	-	-	-	-	-	-	-

Day of Week		Thursday			Friday			Saturday		
Shift		1	2	3	1	2	3	1	2	3
Vacant 20-21*	1,355	0%	0%	0%	0%	0%	0%	0%	0%	0%
		0	0	0	0	0	0	0	0	0
TraPac 22-26	4,250	93%	93%	0%	98%	98%	98%	98%	98%	0%
		3,956	3,956	-	4,156	4,156	4,156	4,156	4,156	-
TraPac 30-33	2,850	51%	51%	0%	0%	0%	0%	94%	94%	94%
		1,461	1,461	-	-	-	-	2,691	2,691	2,691
BEN 35-37	2,257	55%	55%	0%	65%	65%	65%	65%	65%	0%
		1,242	1,242	-	1,462	1,462	1,462	1,462	1,462	-
BEN 38	850	0%	0%	0%	0%	0%	0%	0%	0%	0%
OICT 55-59	6,000	36%	36%	15%	86%	86%	86%	71%	71%	0%
		2,153	2,153	898	5,165	5,165	5,165	4,267	4,267	-
Matson 60-63	2,743	0%	0%	0%	0%	0%	0%	0%	0%	0%
		-	-	-	-	-	-	-	-	-
Howard 67-68**	981	0%	0%	0%	0%	0%	0%	0%	0%	0%
		-	-	-	-	-	-	-	-	-

*Proposed for dry bulk
** Reduced by 965' for turning basin expansion and a further 70' for loss of dolphin

The additional service would increase pressure on the Port's berths on Tuesday and Wednesday, although this would not substantially alter the combined berth occupancy at OICT, Ben E. Nutter, and TraPac.

Slow Growth Berth Occupancy

The unrestrained vessel size Slow Growth scenario featured a single service in 2050 with a vessel in excess of 25,000 TEU: the 2M Alliance's TP8/Orient/PS4/UPAS1 service, with a 28,000 TEU vessel. The second 2M service was estimated to utilize a 22,000 TEU capacity vessel in 2050. Shifting the cargo requirements from one service to the other resulted in a scenario in which each would utilize 25,000 TEU capacity vessels, thereby reducing the combined berth requirements from 3,088 feet to 2,924 feet. The berth occupancy charts are not presented here given the similarity between this scenario and the slow growth scenario. with unconstrained vessel size.

Strong Growth Berth Occupancy

The Strong Growth Scenario with vessels limited to a nominal capacity of 25,000 TEU would require the introduction of four additional services. This includes the re-distribution of container volumes previously assigned to three 25,000 or greater TEU Ocean Alliance services at OICT within the strong growth scenario with unconstrained vessel size, to four services with a vessel capacity of 25,000 TEU or less.

Exhibit 119 shows that the use of the currently vacant Berths 20-21 is required to accommodate the projected vessel calls, as was the case in the strong growth scenario with unconstrained vessel size. Again, Howard Terminal would be able to fulfill this role should Berths 20-21 not be available.

Exhibit 119: 2050 Estimated Berth Occupancy - Strong Growth with Capped Vessel Size

2050 Estimated Berth Occupancy - By Dwell Hours and Berth Length - Strong Growth with Vessels Capped at 25,000 TEU																						
Day of Week			Sunday			Monday			Tuesday			Wednesday			Thursday			Friday			Saturday	
Shift		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
OICT		CEN/BOHAI/CC2/CEN/PCN1/CEN/AC3				40					ALS WB/California Bridge/ECX				36		EX1				36	
		1,462	1,462	1,462	1,462	1,462					1,350	1,350	1,350	1,350	1,350		1,455	1,455	1,455	1,455	1,455	
OICT		PS6				40		TP2/Jaguar/PS3/UPAS 2				36		SSEA/Polynesia		24	WAMS/WCCA2/AZ1		24			
		1,462	1,462	1,462	1,462	1,462		1,462	1,462	1,462	1,462	1,462		1,004	1,004	1,004	1,114	1,114	1,114			
OICT	6000'							FP1				36										
								1,462	1,462	1,462	1,462	1,462										
OICT		OVERFLOW TP2/Jaguar/PS3/UPAS 2				36											PS2/TP7/Lotus				36	
		1,459	1,459	1,459	1,459	1,459											1,459	1,459	1,459	1,459	1,459	
OICT							Columbus JAX/PE1/SEA2/PE1/SEAP PSW				36						TP8/Orient/PS4/UPAS1				36	
							1,462	1,462	1,462	1,462	1,462						1,462	1,462	1,462	1,462	1,462	
TraPac					PS7				40		EC1 WB				36		PS4				36	
					1,462	1,462	1,462	1,462	1,462		1,455	1,455	1,455	1,455	1,455		1,455	1,455	1,455	1,455	1,455	
TraPac					PS3				36													
					1,462	1,462	1,462	1,462	1,462													
TraPac	4250'	HTW/AAS3/GEX				36					PS2/JPSW/PS2				36							
		1,462	1,462	1,462	1,462	1,462					1,350	1,350	1,350	1,350	1,350							
TraPac											PS5				36		Pearl River Express/SC1/PRX/AAS2/PCS1				40	
											1,455	1,455	1,455	1,455	1,455		1,462	1,462	1,462	1,462	1,462	
TraPac	2850'	PSW1/PA	36		OVERFLOW OCEAN ALLIANCE				36		CHX		24							PSW1/PANZ-PSW/V		36
		1,232	1,232		1,461	1,461	1,461	1,461	1,461		1,004	1,004	1,004							1,232	1,232	1,232
TraPac		CPS/CC5	36								California Express				36					CPS/CC5/AAC2/HBB		36
		1,462	1,462								1,462	1,462	1,462	1,462	1,462					1,462	1,462	1,462
Ben E. Nutter		OVERFLOW AC5				36					TPS/Jade Express/AAS4/SC8				36		AC5				36	
		1,232	1,232	1,232	1,232	1,232					1,459	1,459	1,459	1,459	1,459		1,459	1,459	1,459	1,459	1,459	
Ben E. Nutter	2257'																					
Ben E. Nutter	850'																					
Matson	2743'				Hawaii 2		24				Hawaii 1		24									
					1,111	1,111	1,111				1,111	1,111	1,111									
Howard	981'																					
Vacant 20-21	1355'	MPS/MCPS/MPS				36					MPS/MCPS/MPS				36		OVERFLOW TPS/Jade Express/AAS4/SC8				36	
		1,350	1,350	1,350	1,350	1,350					1,350	1,350	1,350	1,350	1,350		1,232	1,232	1,232	1,232	1,232	

As Exhibit 120 reveals, Berths 20-21 would be fully utilized in 15 of the 21 available shifts.

Exhibit 120: Estimated 2050 Berth Occupancy by Terminal - Strong Growth with Capped Vessel Size

Day of Week		Sunday			Monday			Tuesday			Wednesday			Thursday			Friday			Saturday		
Shift		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Vacant 20-21*	1,355	100%	100%	100%	100%	100%	0%	0%	0%	0%	100%	100%	100%	100%	100%	0%	91%	91%	91%	91%	91%	0%
		1350	1350	1350	1350	1350	0	0	0	0	1350	1350	1350	1350	1350	0	1232	1232	1232	1232	1232	0
TraPac 22-26	4,250	34%	34%	34%	103%	103%	69%	69%	69%	0%	100%	100%	100%	100%	100%	0%	69%	69%	69%	69%	69%	0%
		1,462	1,462	1,462	4,386	4,386	2,924	2,924	2,924	-	4,261	4,261	4,261	4,261	4,261	-	2,917	2,917	2,917	2,917	2,917	-
TraPac 30-33	2,850	95%	95%	0%	51%	51%	51%	51%	51%	0%	87%	87%	87%	51%	51%	0%	0%	0%	0%	95%	95%	95%
		2,694	2,694	-	1,461	1,461	1,461	1,461	1,461	-	2,466	2,466	2,466	1,462	1,462	-	-	-	-	2,694	2,694	2,694
BEN 35-37	2,257	55%	55%	55%	55%	55%	0%	0%	0%	0%	65%	65%	65%	65%	65%	0%	65%	65%	65%	65%	65%	0%
		1,232	1,232	1,232	1,232	1,232	-	-	-	-	1,459	1,459	1,459	1,459	1,459	-	1,459	1,459	1,459	1,459	1,459	-
BEN 38	850	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
OICT 55-59	6,000	73%	73%	73%	73%	73%	24%	73%	73%	73%	96%	71%	23%	39%	39%	17%	92%	92%	92%	73%	73%	0%
		4,383	4,383	4,383	4,383	4,383	1,462	4,386	4,386	4,386	5,736	4,274	1,350	2,354	2,354	1,004	5,491	5,491	5,491	4,376	4,376	-
Matson 60-63	2,743	0%	0%	0%	41%	41%	41%	0%	0%	0%	41%	41%	41%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		-	-	-	1,111	1,111	1,111	-	-	-	1,111	1,111	1,111	-	-	-	-	-	-	-	-	-
Howard 67-68**	981	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

*Proposed for dry bulk
** Reduced by 965' for turning basin expansion and a further 70' for loss of dolphin

Berth Occupancy Implications

The consultant team's analysis illustrates the impact of cargo growth, longer vessel dwell times, and greater vessel size on berth occupancy at Oakland terminals.

- Expected moderate or slow growth in vessel sizes through 2050 could likely be accommodated without Berths 20-21 or Howard Terminals.
- Strong growth would require either Berths 20-21 or Howard Terminal's berth space to supplement berths at OICT, TraPac, Ben E. Nutter, and Matson.
- The Moderate and Strong Growth scenarios would likely generate berth congestion at OICT, TraPac, and Ben E. Nutter if no alternatives are available.

- The Matson terminal could offer additional berth capacity if, in the long run, Matson's operational strategies change in that direction.
- The Ben E. Nutter terminal may be particularly vulnerable to berth congestion, as its 2,257 foot berth length is not sufficient for two 1,200 foot vessels. Berth 38 will not be usable once the smallest vessels calling Oakland pass about 700 feet in length.
- The Berths 20–21 wharf face, at 1,355 feet, would limit vessels calling there to about 1,200 feet (about 12,000 TEU).
- Reduced by about 965 feet to allow for turning basin expansion and a further decrease of 70 feet due to the loss of the dolphin, the 2,016 foot Howard Terminal berth length would become 981 feet. This would not be long enough for vessels likely to be calling at the Port in 2050 without modification (e.g. extension to the East).

Ancillary Services Land Use

Need for Ancillary Services

As established in BCDC's consideration of the Oakland Army Base redevelopment project, efficient operation of container ports requires some services that are not provided by or within the marine terminals. While the full range of ancillary functions can be very large, in the context of the Seaport Plan the relevant functions are those with strong reasons to be located in the immediate port facility.

Exhibit 121 shows the Port of Oakland parcels designated for port priority and available for ancillary functions and facilities:

- The Seaport Logistics Complex, at about 149 acres.
- The 555 Maritime St. Complex, at about 78 acres.
- The "CBP Triangle," at about 7 acres.
- The "Outer Harbor Extension," at about 20 acres.

Exhibit 121: Port of Oakland Ancillary Use Sites

2001 Ancillary Services Study

In connection with development plans for the former Oakland Army Base (OAB), the Port of Oakland engaged a consultant team lead by Tioga to determine the need for ancillary services in the immediate port area, and their land requirements, out to 2020. The Port Services Location Study was completed in 2001.

The consultant team identified a narrow range of functions and facilities that should preferably be located in the immediate vicinity of the Port:

- **Overnight parking for drayage tractors, containers on chassis, and bare chassis.** Lacking parking in the port area, many more tractors and chassis would be parked in the residential or commercial neighborhoods surrounding the port, and would incur additional miles of travel and generate additional emissions moving back and forth.
- **Short-term truck parking.** Truck drivers need a safe, legal place to stop for rest breaks or while waiting for their next assignment. Here too, lack of parking space in the port area would tend to push trucks into adjacent neighborhoods.
- **Truck services.** Wherever possible, truck drivers should be able to access fuel, charging facilities, scales, food service, and other necessities without driving to and through adjacent neighborhoods.
- **Heavy Cargo Facilities.** The need for heavy cargo facilities identified in the 2001 study included transloading and container freight stations to shift cargo between truck, rail, and marine modes. The Port of Oakland has long handled substantial volumes of heavy commodities, particularly agricultural products. Many of those commodities would exceed highway weight limits if loaded to the full ocean-going capacity of a marine container. It is thus common practice to move these commodities to and from the Port area in smaller truckloads or in rail cars, and make the transfer to and from marine containers at or near the port along so-called "overweight corridors". This strategy minimizes moving heavy containers and other cargo to and from the port on public roads.

- **Reefer Container Depots.** The Port of Oakland is a major export point for California produce, Midwestern meat and poultry, and other commodities that need refrigerated containers. These "reefer" containers may need inspection, cleaning, and refueling between trips; pre-cooling before loading; and calibration and temperature checks after being loaded. Locating these functions at or near the port minimizes the need for drayage firms to shuttle them back and forth over public streets.

Exhibit 122 summarizes the land requirements estimated in the 2001 study.

Exhibit 122: 2001 Estimate of Ancillary Land Requirements

Year	Drayage Tractor Parking	Container/ Chassis Parking	Short-Term Parking	Truck Services	Heavy Cargo Facilities	Working Reefer Depots	Total Core Service Acres	Port Land	Est. Usable Port Land (90%)	Gap
2000	5	7	1	4	36	18	71	125	113	-
2005	7	8	2	4	44	24	88	180	162	-
2010	9	10	2	7	56	30	114	155	140	-
2015	12	12	5	7	70	38	143	130	117	26
2020	16	14	8	8	85	47	178	105	95	84

For this study, the consultant team re-examined the need for each facility type and the land available to locate them with the immediate Port of Oakland area.

Truck Services

The Port of Oakland has had a truck service center under development for several years. The project, currently described as the "Oakland Energy & Truck Travel Center," will include:

- Truck fueling and charging.
- Truck scales
- Convenience store/travel center
- Limited maintenance/ testing facilities.
- Limited truck parking.

The current proposed plan would cover about 8.26 acres, as shown in Exhibit 123. The proposed site is within the "Outer Harbor Extension" area, as indicated in Exhibit 124. Exhibit 124 also shows the location of Oakland Marine Support Services (OMSS) on roughly 10 acres of City of Oakland land outside the port priority area. OMSS offers truck parking and a range of truck support services.

Exhibit 123: Oakland Energy & Truck Travel Center

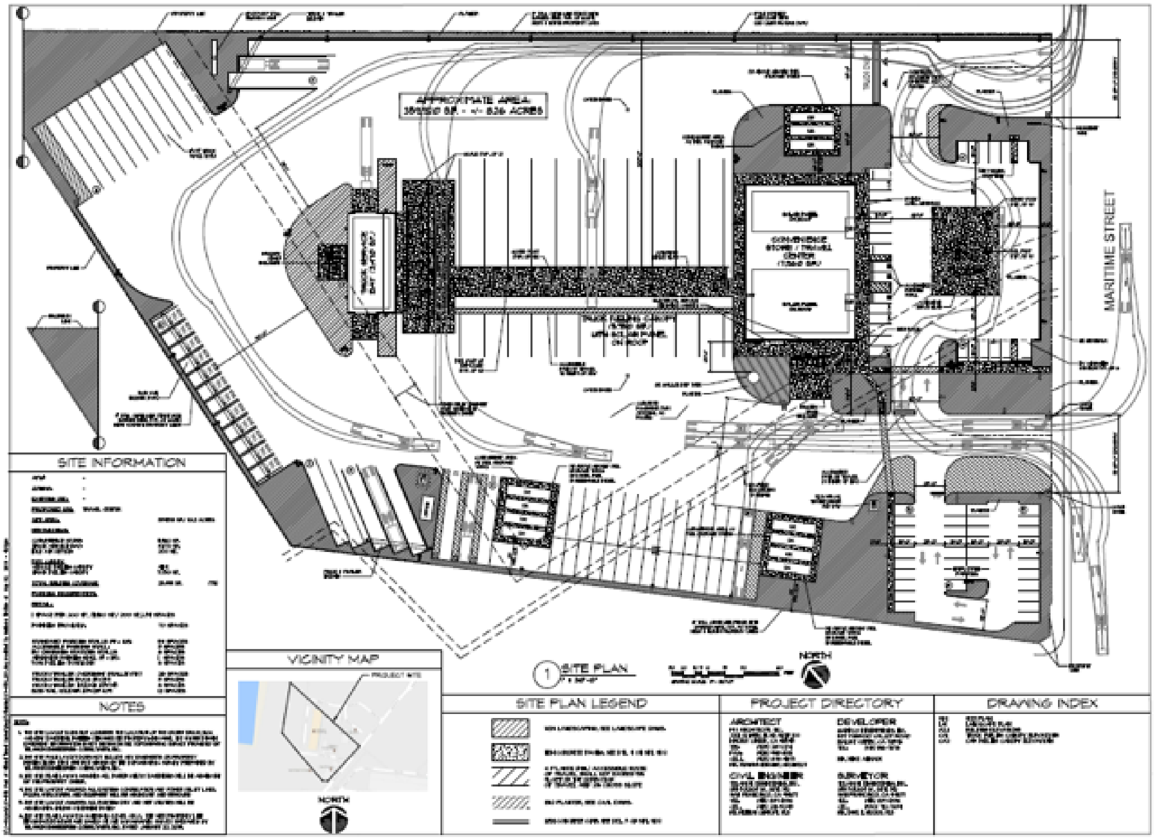
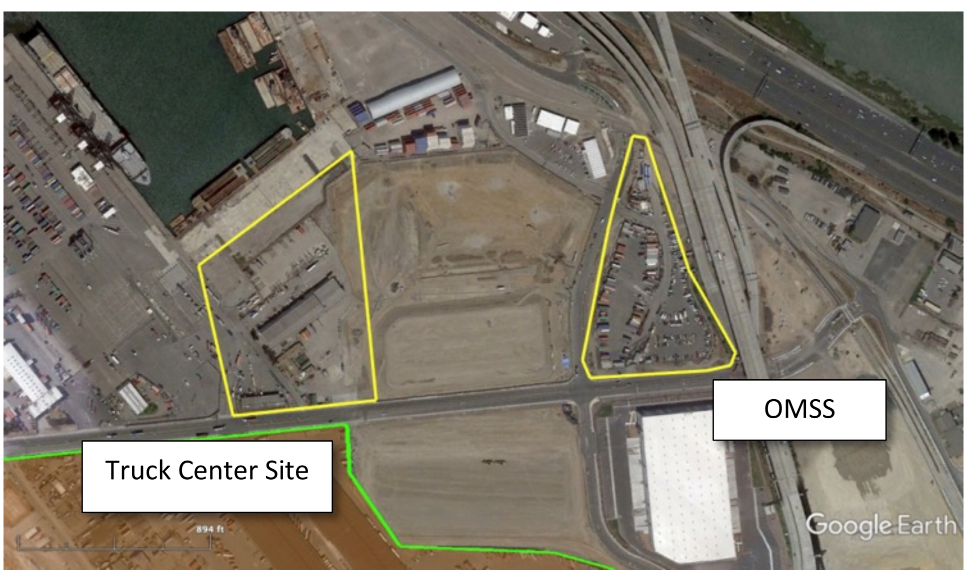


Exhibit 124: Location of Proposed Truck Service Center and OMSS



The proposed truck service center and OMSS together would effectively fulfill the need for truck services identified in the 2001 study, which are largely independent of cargo volume.

Heavy Cargo Facilities and Reefer Container Depots

The 2001 study estimated the required space for heavy cargo facilities at 85 acres (Exhibit 122). Using the same model with cargo growth extended to 2050 yields a long-term estimate of 109 acres for the moderate growth scenario, 82 acres for slow growth, and 147 acres for strong growth. The study also identified a need for 47 acres of reefer depot facilities. Extending the model to 2050 implies a need for 59 acres with moderate growth, 45 acres with slow growth, or 80 acres with strong growth.

The need for such facilities is being met by development on Port-owned seaport priority land, on City of Oakland land, and on private, non-priority land.

555 Maritime St Complex

The overall port-owned 555 Maritime St. Complex (Exhibit 125) covers about 79 acres. Besides Cool Port itself at 25 acres, the land is currently used by GSC Logistics and Unicold for cargo transfer, and by ConGlobal for container depot operations. The Port's current plan is to continue developing the remaining site acreage for ancillary services, as its physical and operational separation surrounded by rail lines prevents efficient integration with marine terminal operations.

Exhibit 125: 555 Maritime St Complex

Cool Port. Cool Port at the Port of Oakland is a 275,000 square foot state-of-the-art refrigerated transload and distribution facility with supporting rail infrastructure on approximately 25 acres centrally located within the Port complex (Exhibit 126).

Exhibit 126: Oakland Cool Port

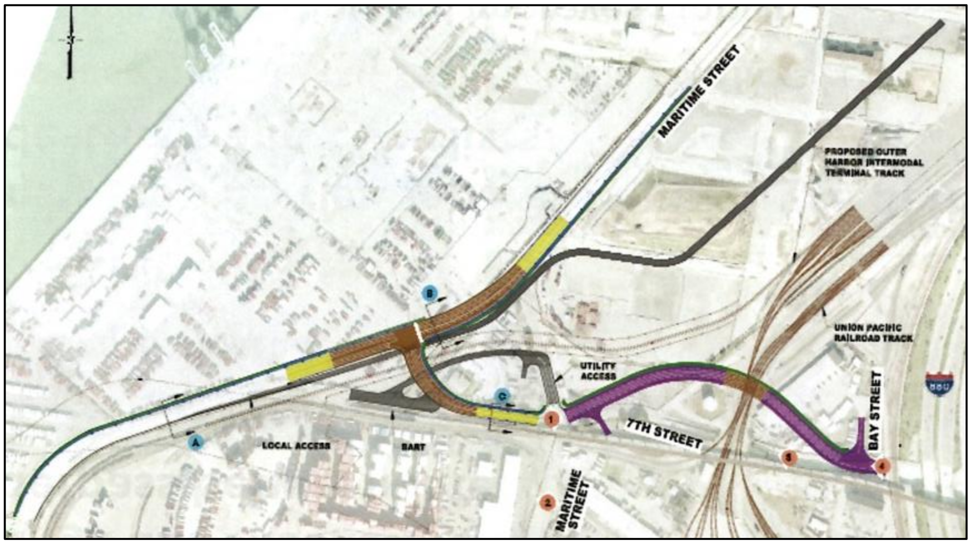
Phase I construction started in April/May of 2017, and the facility opened on November 1, 2018. Cool Port LLC has the option to expand on 15 acres of adjacent land. If Phase 2 is approved, work would start sometime in 2024.

Seaport Logistics Complex/CenterPoint

A large portion of the total Port land available for ancillary uses is the former Oakland Army Base, as shown in Exhibit 127. Designated as the "Seaport Logistics Complex," the site comprises about 149 acres, all in port priority. As indicated in Exhibit 128, a small portion of the acreage will be occupied by the 7th St. Grade Separation realignment of Maritime and 7th Streets.

Exhibit 127: Oakland Army Base/Seaport Logistics Complex

Exhibit 128: 7th St Grade Separation Project



As of early 2019, the first phase of the Seaport Logistics Complex is under construction in cooperation with CenterPoint. This will be a 460,000 s.f. distribution and transloading center on a 29-acre site. The Port expects that the remaining 120 acres will be developed in a similar fashion over multiple phases.

Portions of the site are currently (early 2019) in use by:

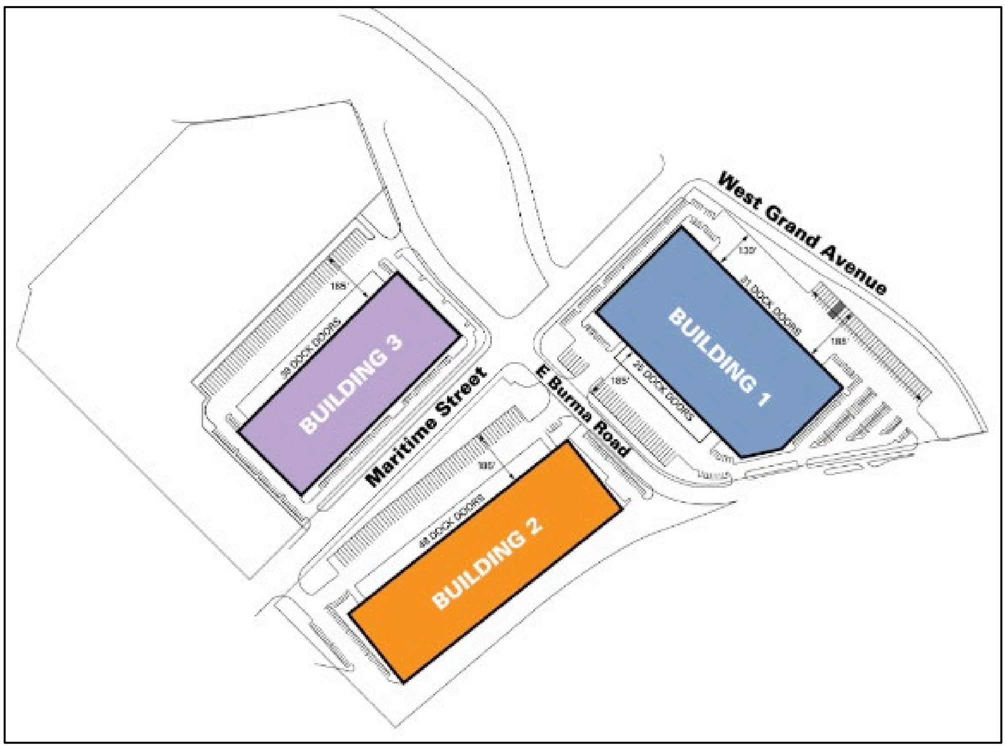
- Shipper's Transport Express, as an off-dock parking lot for OICT.
- Impact Transportation, engaged in cargo transloading and truck drayage.
- Port Transfer, Inc., engaged in overweight cargo transloading.

City of Oakland/ProLogis

The City of Oakland portion of OAB (Exhibit 129) is being developed in a multi-phase program in cooperation with ProLogis. The completed Building 1 is shown in Exhibit 127. Exhibit 130 displays the build-out plan for all three buildings. The overall ProLogis site in Exhibit 129 is about 63 acres.

Exhibit 129: City of Oakland/ProLogis Site

Exhibit 130: City of Oakland/ProLogis Development



"CBP Triangle"

The CBP Triangle shown in Exhibit 121 is about 7 acres, and is currently used by CBP. As Exhibit 128 implies, however, significant use of the site for ancillary uses will be pre-empted by the 7th St. Grade Separation Project.

Outer Harbor Extension

Much of the Outer Harbor Extension will be used for the truck service center. The remaining portions of the 20-acre site include:

- A dredging material re-handling site, which is critical to the Port's ability to conduct maintenance dredging and is not suitable for other ancillary uses.
- AMNAV Maritime Tug Service, which has provided Bay Area tug services since 1976. This 5-acre portion of the property is thus in a critical ancillary use that requires water access.

The Outer Harbor Extension will thus have about 13 acres in ancillary use – 5 acres for AMNAV and 8 acres for the truck center.

Union Pacific

Union Pacific has two sites being used for ancillary port services. They are currently used by PCC Logistics and Pacific Transload, both for transloading cargo and related services. The two parcels total about 17 acres (Exhibit 131).

Exhibit 131: Union Pacific Ancillary Sites

Truck Parking

2001 Estimate

The 2001 Tioga report estimated a 2020 need for 16.0 acres of overnight tractor parking and 14.0 acres of overnight container and chassis parking, forming the basis for the combined Port/city commitment of 30.0 acres in the OAB EIR. No separate commitment was made for short-term truck parking.

2016 Truck Parking Update

In view of changing cargo volumes and circumstances, the Port asked Tioga to revisit the parking requirement estimates in 2016. There was ongoing concern within the Oakland community, particularly in West Oakland, that drayage tractors and containers would be parked on city streets or at other undesirable locations. Tioga selectively revised and updated the truck parking model to reflect survey and interview findings regarding the need for short-term and overnight truck and container chassis parking, and the ways in which that parking need was being filled.

The earlier estimate was based on 2001 expectations of cargo growth, rail intermodal share, parking practice, and turn times. Many of those factors had changed by 2016.

Some of those factors were expected to reduce parking needs

- Slower cargo growth was expected to result in lower overall cargo volume, fewer truck trips, and reduced parking needs.
- More working days per year (i.e. Saturday gates) were expected to reduce the number of trucks and parking spaces needed to handle the same cargo volume.
- Greater use of company yards and locations outside of Oakland, as revealed in the recent trucker survey, is expected to materially reduce the need for overnight tractor parking in the Port area.
- A greater percentage of rail intermodal moves should also reduce the required truck fleet and parking needs because rail intermodal moves typically have more daily turns.

The Port and port terminals operators also introduced a number of practices in 2016 that would also reduce the long-term need to park tractors or container on chassis:

- Terminal appointment systems for truck drivers will reduce turn times, increase the productivity of each truck, reduce the number of trucks needed, and improve the ability of trucking companies to schedule their operations.
- “Extended gates” open during the night and evening will allow truckers to extend their working day and reduce the need to pre-pull and park containers on chasses or stage returned container for the next morning.

The main factor that was expected to increase the truck fleet requirement and thus overnight parking needs is the reduction in estimated daily turns. Tioga's trucker survey reported about half as many daily average turns as were assumed in the 2001 study.

As Exhibit 132 shows, the net effect of these factors discussed was to reduce the estimated 2020 overnight tractor parking requirement from 16.0 acres to 11.5 acres, and the overnight container and chassis parking requirement from 14.0 acres to 10.6 acres. The reduction in daily turns was expected to require a 64% larger truck fleet, the larger fleet size should have been more than offset by the reduced use of on-port parking by companies with their own yards or based out of Oakland.

Exhibit 132: 2020 Overnight Truck Parking Requirements

Year	Drayage Tractors	Container & Chassis	Tractor & Chassis	Total
2001 Summary Acreage Requirements				
2000	4.8	6.6	na	11
2005	7.2	8.1	na	15
2010	9.4	9.8	na	19
2015	12.1	11.8	na	24
2020	**16.0**	**14.0**	na	**30.0**
Updated Scenario Summary Acreage Requirements				
2020	**11.5**	**10.6**	na	**22.1**
Daily Tractors Needed:		**4,108**		
2001 Estimate		**2,070**		

At the Port's request, Tioga also used the model to create three other scenarios:

- Baseline: current 2015 numbers and intermodal share of 15%.
- Future (2020) – 3.2M TEU with a 27% intermodal share (as projected in the 2012 OAB EIR Addendum).
- Future (2035 Full Build-out) – 4.05M TEU with a 40% intermodal share.

The results suggested that the 30-acre Port/city commitment for overnight tractor parking space would be more than adequate for "foreseeable conditions," which at that time extended through 2035. The sensitivity analysis indicated that the only circumstance under which the demand for overnight tractor parking is likely to exceed 30 acres would be high trade volumes combined with a resurgence in Oakland-based drayage firms without their own yards.

Updated Truck Parking Forecast to 2050

Both the cargo growth outlook and the truck operating conditions have changed since 2016.

While trade volumes in excess of 4 million annual TEU are forecast by 2050, a resurgence in Oakland-based drayage is counter to both industry trends at the time and industry trends at present. There is an ongoing industry trend towards company yards for security and logistics reasons.

At present, as it was in 2016,overnight tractor parking is concentrated at sites out of Oakland, at company yards, and at the ABM (AMPCO) and OMSS lots. Overnight chassis or container on chassis parking is likewise concentrated in company yards and at ABM. Daytime tractor parking is only needed for driver breaks, waiting for gate openings, or waiting for appointments. Daytime chassis and container parking is mostly confined to ABM, with no reported use of city streets in the 2016 study.

Tioga re-ran the truck parking model to determine the impact of new cargo forecasts extending to 2050, and to determine what other factors that could change between 2019 and 2050 would have a significant impact on truck parking needs.

Exhibit 133: BCDC Forecast Ancillary Services Truck Parking Model - 2050 Scenarios

Inputs

Scenario	Annual TEU	% Rail	Day Gates	Night Gates	Night Gate Ute %	Total Equivalent Gates	Parking Space Utilization
2001 Estimate for 2020	3,939,575	42%	250	0	0%	250	80%
2016 Update to 2020	2,283,942	15%	260	0	0%	260	80%
Moderate Growth	5,187,588	15%	300	300	10%	330	80%
Slow Growth	3,862,435	15%	250	125	5%	256	80%
Strong Growth	7,038,560	17%	300	300	25%	375	85%

Outputs

Scenario	Drayage Fleet Tractors	Overnight Parking Acres			Day Use Parking Acres		
		Drayage Tractors	Container & Chassis	Total	Drayage Tractors	Tractor & Chassis	Total
2001 Estimate for 2020	2070	16.0	14.0	30.0	2.9	5.2	8.1
2016 Update to 2020	3540	9.9	8.9	18.8	1.3	0.7	2.0
Moderate Growth	6773	14.4	15.3	29.7	2.1	1.2	3.3
Slow Growth	6494	13.8	14.6	28.4	2.0	1.1	3.1
Strong Growth	6450	13.4	17.1	30.5	2.3	1.3	3.7

The modeling results showed that the increased need for trucking and truck parking from cargo growth tends to be offset by the measures terminals take to accommodate that growth. Notably, extending gate hours into night shifts reduces the number of trucks that would otherwise be needed and keeps them busy more and parked less. The Port's FITS program will include a parking information system that should increase utilization of available space. The result is that overnight parking requirements remain at roughly 30 acres. Day use parking needs rise slightly, but are limited for the same reasons. Day use parking is typically accommodated in the same lots that provide overnight space.

Summary of Ancillary Service Needs

A comparison of the acreage required for ancillary services in the Port area and the acres estimated to be required under the three container cargo growth scenarios is provided in Exhibit 134.

Exhibit 134: Summary Ancillary Acreage Needs

Acres Required	Truck Services	Overnight Truck Parking	Short-Term Truck Parking	Heavy Cargo Transloading	Reefer Depots	Total
Moderate Growth	8	30	3	109	59	**209**
Slow Growth	8	28	3	82	45	**167**
Strong Growth	8	30	4	147	80	**269**
Acres in Ancillary Use and Available	**Seaport Logistics Complex**	**555 Maritime St Complex**	**Outer Harbor**	**City of Oakland**	**Union Pacific**	**Total**
As of Early 2019	149	78	13	63	11	**314**

As of early 2019, there were about 314 acres of land in the immediate Port area either already in an ancillary use (e.g. Cool Port or the two facilities on Union Pacific Land); under development for an ancillary use (e.g. Center Point Phase 1 or Prologis Buildings 2 and 3); or available for long-term ancillary use.

Estimated acres required for all ancillary uses range from 167 in the slow growth scenario to 269 in the strong growth scenario.

The comparisons in Exhibit 134 suggest that there is adequate space within the Port of Oakland complex for ancillary services to support projected cargo growth in all three scenarios. The Port of Oakland plans to eventually develop all the Port-owned land listed in Exhibit 134 in functions that will encourage and support marine cargo growth. The City of Oakland is also on a path to do the same.

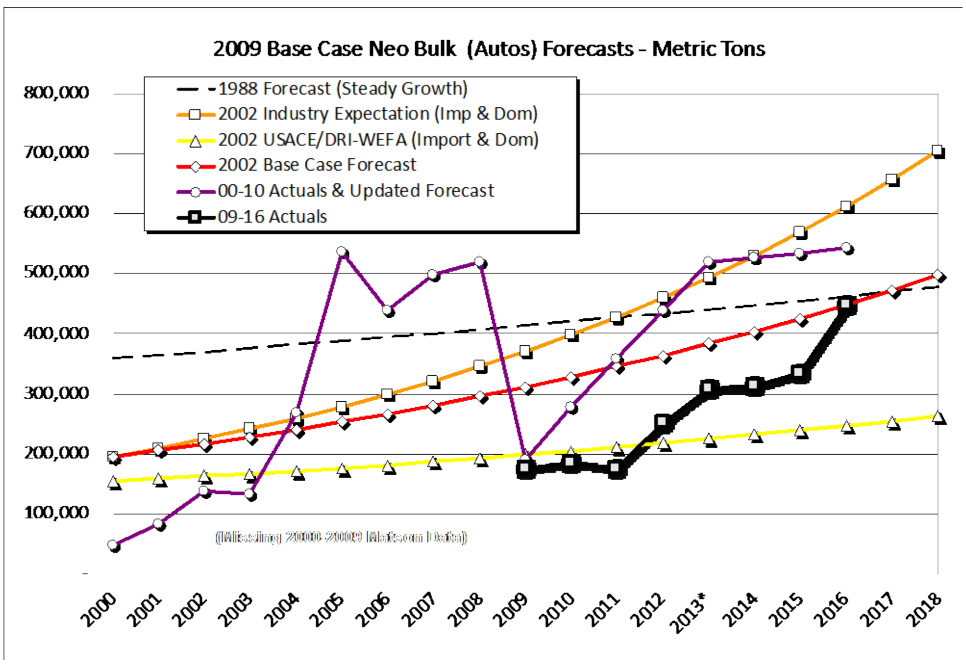
V. Ro-Ro Cargo Forecast and Capacity Analysis

Ro-Ro (Neo-Bulk) Cargo Review

The Seaport Plan has used the term "neo-bulk" to describe cargoes that are neither containerized nor bulk, but do not require the traditional piece-by-piece handling of break-bulk cargo. Roll-on roll-off (ro-ro) shipment of autos and other vehicles have come to dominate this cargo segment, and is the only active "neo-bulk" category at SF Bay Area ports. The analysis therefore uses the "ro-ro" nomenclature for clarity and consistency with industry terminology.

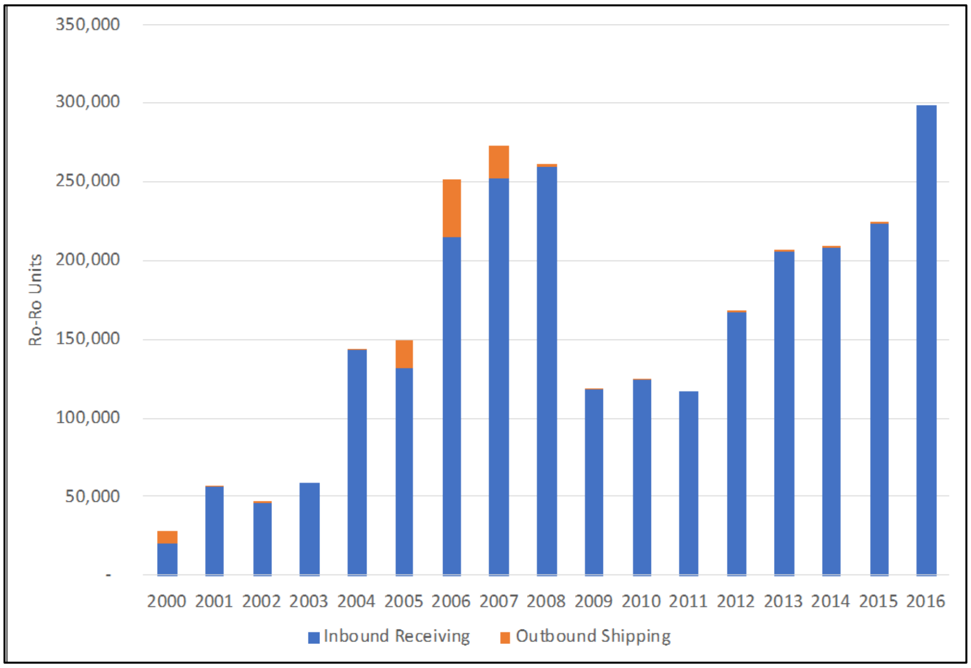
As shown in Exhibit 135, the import and export auto trades did not recover as strongly as expected from the recession, but have since grown to near the predicted volume by 2016 (complete 2017-2018 are not yet available).

Exhibit 135: Ro-Ro Auto Trade Forecasts



The Ports of Richmond, Benicia, and San Francisco are currently handling import and export autos in ro-ro vessels. Exhibit 136 shows estimated import and export vehicle counts for 2000-2116. The data show the dominance by the import flow.

Exhibit 136: Bay Area Ro-Ro Vehicle Trade, 2000-2016



Discussions with the Ports of Richmond and Benicia indicate that those facilities are approaching capacity. For ro-ro facilities capacity is determined primarily by 1) parking space, and 2) the average dwell time of vehicles in the parking space. Capacity is further affected by peaking, with closely-spaced vessel arrivals or seasonal sales variations leading to periodic surges.

The Port of San Francisco is handling Tesla exports at Pier 80. Tesla exports have grown rapidly in the last 2–3 years, but the long-term trend is not established.

Ro-Ro (Neo-bulk) Shipping Trends

For roll-on/roll-off (Ro-Ro) trade, mainly automobiles and vehicles, the Ports of San Diego, Long Beach, Hueneme, Benicia, San Francisco, and Richmond all participate and compete. Ro-Ro facilities are principally of two types: brand-linked (such as the Toyota import facility at Long Beach) and operator-based (such as the Pasha facilities at San Diego and San Francisco). Ports and terminal operators compete for multi-year contracts with major auto importers and on a shipment-by-shipment basis for other flows. The key factors in this competition are:

- Fit within the importer's international market strategy.
- Access to major consumer markets.
- Costs of ocean shipment, port handling, and vehicle processing.
- Trucking costs to local and regional markets.
- Rail access, service, and cost to intrastate markets.

From the above factors, most often geography and market access are primary factors, and transportation cost is a secondary factor.

The Ports of Richmond and Benicia are entry and distribution points for imported autos, and Pasha has recently commenced auto operations at the Port of San Francisco. Each manufacturer/importer tends to choose one or more ports as entry points for multi-year commitments. Ports and auto terminal operators, therefore, tend to compete for these long-term commitments rather than shipment-by-shipment. To the extent that one importer may bring in autos to more than one port, the port terminal operators may compete for volume and territory, as do distributors of other goods.

Roll-on/roll-off (ro-ro) shipping handles vehicles and other cargo (e.g. industrial equipment) that can be rolled on and off specialized vessels. Ro-Ro vessels are essentially floating parking lots (Exhibit 137), and are loaded and discharged via ramps (Exhibit 138).

Exhibit 137: Ro-Ro Vessel

Exhibit 138: Ro-Ro Vessel Discharge

The Bay Area has three active ro-ro terminals:

- BPTC at Benicia (auto processing is done by Amports).
- Port Potrero, operated by AWC, at Richmond.
- Pier 80, operated by Pasha, at San Francisco.

The primary market for ro-ro operations has long been import autos and trucks. Both Richmond and Benicia have also handled much smaller volumes of export vehicles. The Pasha operation at Pier 80 is an exception, as it mostly handles Teslas for export to China and elsewhere.

The volume growth of ro-ro vehicle shipments has been tempered by the tendency of foreign manufacturers to build U.S. assembly plants for their most popular vehicles in the U.S. market:

- Toyota has assembly plants in Kentucky, Indiana, Texas, and Mississippi.
- Honda has assembly plants in Ohio, Alabama, and Indiana.
- Nissan has assembly plants in Tennessee and Mississippi.
- Subaru has an assembly plant in Indiana.
- Hyundai has an assembly plant in Alabama.
- Kia has an assembly plant in Georgia.
- Volkswagen has an assembly plant in Tennessee.
- Volvo has an assembly plant in South Carolina.
- Daimler (Mercedes) has assembly plants in Alabama and South Carolina.
- BMW has an assembly plant in South Carolina.

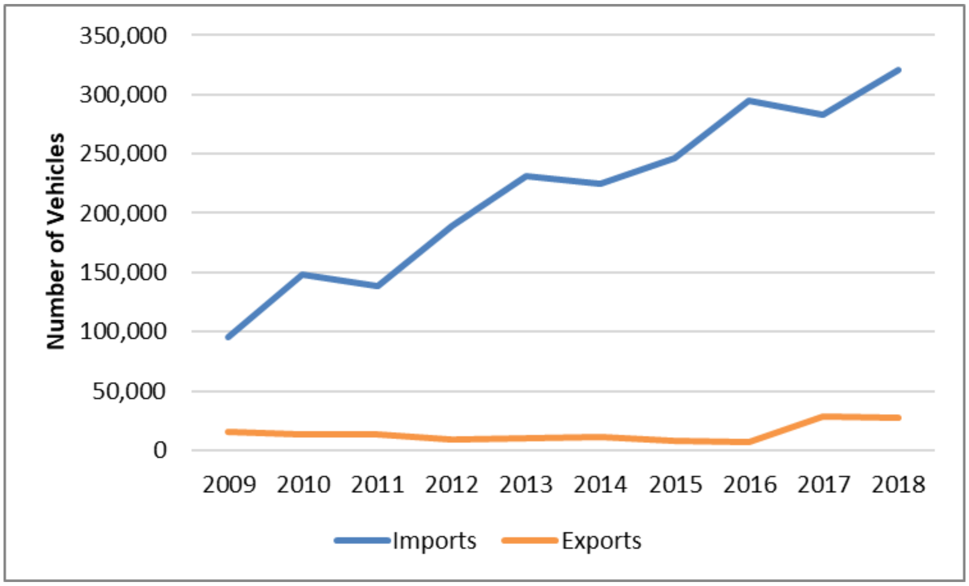
Many industry observers have predicted that the U.S. would eventually begin importing Chinese autos from manufacturers such as Chery. This predicted trend has not yet resulted in significant imports of Chinese brands. If Chinese makers gain a significant foothold in U.S. markets, they may follow other manufacturers in establishing U.S. assembly plants.

There are also autos made in China for the U.S. market by non-Chinese manufacturers. Buick, Cadillac, and Volvo, all produce vehicles in China for export to the U.S. Those imports have been curtailed due to the current trade war with China.

The quantity of imported passenger vehicles has increased rapidly over the past decade, substantially outpacing the growth in population of the 19-county region. In 2018 United States International Trade Commission reported that the San Francisco district imported a total of 320,873 light vehicles and 12,259 pickup trucks (Exhibit 139). The import of passenger vehicles has increased consistently over the past decade, with an annual growth rate of 10.2 percent between 2010 and 2018 (again, 2009 is excluded due to the impact of the recession). In contrast, the import of pickup trucks was minimal until 2016. In both cases this is markedly different to the growth rates experienced at the national level. Between 2010 and 2018, the number of passenger vehicles imported increased by 4.0% per year, while pickup trucks increased by 13.2% per year.

The U.S. Census Bureau reported that 2.4 million passenger vehicles were imported from Mexico to the U.S. in 2017 which represents a 71% increase from 2012. This is anticipated to increase to nearly 5 million vehicles by 2020 (Automotive News).

Exhibit 139: Import and Export of Passenger Vehicles to the San Francisco District



Imports accounted for 92% of the total international movement of passenger vehicles and pickup trucks in 2018, as just 27,537 passenger vehicles and 2 pickup trucks were exported (Exhibit 140). Exports of passenger vehicles increased by 9.2% annually between 2010 and 2018, although exports increased over threefold between 2016 and 2018, likely due to Tesla as 39,234 solely electric vehicles were exported in 2017 and 2018. The growth rate in exports at the national level is once again different: between 2010 and 2018, the number of passenger vehicles exported increased by 1.8% per year, while pickup trucks increased by 1.9% per year.

Exhibit 140: Import and Export of Pickups <5 Tons from the San Francisco District

Discussions with ro-ro terminal operators and port staff reveal that different manufacturers have different import and processing strategies.

- Some manufacturers import “plain vanilla” vehicles and move them to dealers with minimal processing. Accessories are then added by the dealers. The time at the port depends on whether they are moving in volume by rail (3-5 days at port) or in smaller lots by truck (7-15 days).
- Other manufacturers process “plain vanilla’ vehicles and add options and accessories at the port before movement inland. This strategy leads to longer port dwell times, a range of roughly 7-30 days.

Manufacturers tend to adjust their strategies back and forth over time, so a terminal handling multiple vehicle lines will experience an average dwell of around 15 days and a throughput averaging about 1,700 vehicles per acre per year.

The growing size of vehicles, particularly the size of dual-cab pickups, reduces annual throughput capacity per acre. Autos can be parked at about 250 per acre for rail shipping or 120 per acre for shipping by truck. Large trucks can be parked at 70-100 units per acre.

Richmond. Auto handling at the Port of Richmond is currently managed by Auto Warehousing Co. (AWC). AWC also operates auto terminals at Portland, Vancouver, Tacoma, and multiple East and Gulf Coast ports, as well as at inland rail hubs. Subaru, Honda, and Ford autos are currently imported through Richmond.

- Hondas and Fords pass through the terminal with minimal processing, spending 2-4 days at Richmond.
- Subarus undergo extensive processing and accessory installation, and typically spend several days at the port.

The Port Potrero ro-ro terminal is currently operating near capacity, sometimes receiving as many as four vessels in 10 days. The Port is seeking ways to expand ro-ro operations, including the use of off-terminal parking.

[detailed data pending]

Benicia. In a late 2018 interview, Amports CEO Steve Taylor noted that Amports is developing a new port about 15 miles east of its dedicated auto terminal in Benicia after signing a long-term lease on a 100-acre former paper mill site in Antioch. Mr. Taylor said Benicia is at capacity, on pace for 250,000 vehicles, and the new development will have room to move 150,000 to 175,000 vehicles per year.

The Volkswagen Group of America opened a new processing facility at Benicia in February 2018, and expects to process 40,000 VW, Bentley, Audi, and Porsche cars annually. BPTC actually moved 203,928 vehicles through Benicia in 2018, suggesting that the 645 acre facility is operating at roughly 82% of capacity. The previous peak was 200,608 annual units in 2008, on the brink of the recession.

Since volumes recovered from the recession in 2013, the volume through Benicia has grown at a CAGR of 8.7%. At that rate, the Benicia facility will have reached capacity in 2021. The combined Benicia and Pittsburg capacity will have been reached by about 2028, even if the Pittsburg facility is not used for other purposes (such as domestic auto processing).

San Francisco. Pier 80 is a 60-acre facility with two warehouses and four berths. Pasha, a major vessel operator and auto handling organization, signed a 15-year lease for Pier 80 in 2016. Pasha moved 43,204 export autos, primarily Teslas, through SF Pier 80 in 2018, up from 24,688 in 2017.

Reportedly, part of the attraction of Pier 80 for Pasha was its underutilization compared to Benicia and Richmond, which are already operating near capacity. Pasha believes that when Pier 80 is completely renovated, it will be able to handle 150,000 vehicles a year and around 100 ships. (American Journal of Transportation - 6/12/17). On that basis, Pier 80 was operating at about 29% of capacity in 2018.

Tesla has announced ambitious production and export plans, but not all of those plans have come to fruition. For example:

> "Tesla plans to be shipping around 3,000 Model 3 vehicles per week to Europe starting in February [2019], according to the port handling company that is preparing to receive them in Belgium. The volume is expected to be quite significant considering Tesla has been able to maintain a demand of over 4,000 Model 3's per week in North America and the demand for the vehicle is expected to be similar in size in Europe." - *Electrek - 12/12/18*

As of April 2019, Tesla is constructing an assembly plant in China, with production of the Model 3 set to commence in late 2019. The stated production target of the facility is 250,000 vehicles per year initially and thereafter increasing to 500,000 vehicles per year. While other Tesla models would still be exported from the San Francisco area it is therefore unlikely that significant numbers of the more affordable Model 3 will be exported to China.

In the short term the primary risk to vehicle imports and exports is automobile tariffs that could be levied in both trade directions as part of a trade dispute with China and the E.U. Drewry reported that if tariffs were implemented in the second quarter of 2019 the most negative effect would be expected between 2020 and 2021. Although Canada and Mexico would likely be exempted from any vehicle-related tariffs, the impact of reduced imports from Japan and Europe on the Bay Area's ports would be significant.

If tariffs on vehicles are avoided it is possible in the mid-term that imports from China will increase as the manufacturing of Chinese-brands (as opposed to European and American brands built in China) matures.

In the long term the transition to autonomous driving vehicles may have a significant impact on the number of vehicles that households own, with numerous companies exploring the possibility of providing driverless fleets that can be summoned as needed. The outlook for the production of autonomous vehicles varies to a large degree. In 2018, Credit Suisse predicted that by 2040 just 14% of global car production will be comprised of self-driving vehicles, while Tesla recently announced that it expects its own fully autonomous vehicles to be operational by 2020, including its fleet of "robo-taxis". While the speed of the transition to autonomous vehicles remains hard to predict it is likely that by 2038 there will be an increased use of "on-call" car services that will potentially reduce vehicle ownership at the household level from multiple vehicles to a single vehicle. This in turn could significantly decrease the number of vehicles imported to the U.S.

Outlook

The outlook for ro-ro cargo through San Francisco Bay depends on the growth in import and export auto volume, and on how many vehicles can be stored, processed, and moved through Bay Area facilities.

Growth in import and export vehicle flows depends on:

- Demand for foreign-built vehicles in the U.S., and for U.S.-built vehicles in foreign countries.
- Tariffs, quotas, and other trade barriers.
- Location of new foreign-brand assembly plants in the U.S. and U.S.-brand assembly plants in foreign countries.
- The demand for personal versus shared vehicles over the next decades.

The volume through the Bay Area also depends on market share shifts. Specific import brands could change ports, either to or from the Bay Area. While the consultant team did not attempt to forecast such shifts, they should be recognized as one factor that could push future volumes higher or lower.

The ability of Bay Area ro-ro terminals to accommodate the expected flows will depend on the number of vehicles that can be stored and processed through an acre of land, currently averaging about 1,700 vehicles annually.

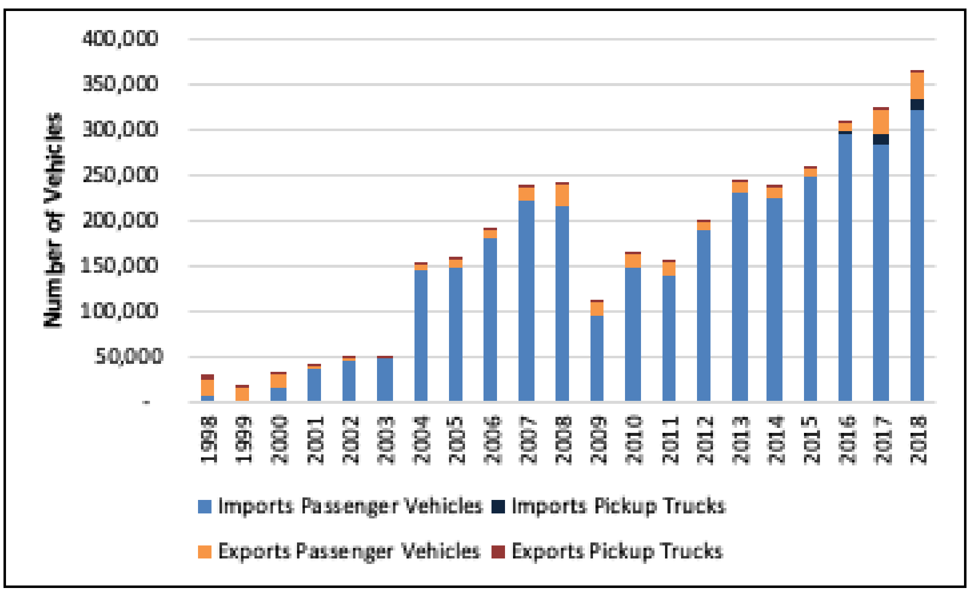
- The mix of vehicle sizes will affect the space required. More imports of large SUVs and double-cab trucks, for example, will increase space requirements and decrease throughput.
- The average time each vehicle spends at the port (dwell time).
- The share of rail versus truck moves; rail-destined vehicles can be parked closer together and typically have shorter dwell times.

The forecast and capacity analyses that follow attempt to capture these influences in a series of representative scenarios.

Current Ro-Ro Cargo Flows

The Ports of Richmond, Benicia, and San Francisco import and export automobiles in ro-ro vessels. Passenger vehicle counts for the Bay Area were obtained from the Office of Transportation and Machinery at the International Trade Administration (a bureau within the U.S. Department of Commerce) as port-provided data were inconsistently recorded in units and tons.vii Exhibit 141 shows the import and export vehicle counts between 1998 and 2018. The data show the dominance of imported vehicles and in particular the importance of passenger vehicles, which accounted for 93 percent of the total light vehicle movements over the past decade.

Exhibit 141: Bay Area Ro-Ro Vehicle Trade



Two factors have begun to decrease the dominance of passenger vehicle imports in Bay Area ro-ro activity:

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vii Passenger vehicles were defined using the following Harmonized Tariff Schedule codes: 8703.21, 8703.22, 8703.23, 8703.24, 8703.31, 8703.32, 8703.32, 8703.33, 8703.40, 8703.50, 8703.60, 8703.70, 8703.80, 8704.21, and 8704.31. This includes spark-ignition and compression-ignition internal combustion engines, hybrid vehicles, electric vehicles, and vehicles for goods transport (including pickup trucks) with a gross vehicle weight not over five metric tons.

- Pickup trucks imports that began in 2016 accounted for almost four percent of total vehicle imports in both 2017 and 2018 (Exhibit 142).
- Passenger vehicle exports, which averaged around 12,400 per year between 2008 and 2016 but increased to around 28,000 per year in both 2017 and 2018, in large part due to the export of Tesla vehicles (Exhibit 143).

Exhibit 142: Pickup Truck Imports and Exports

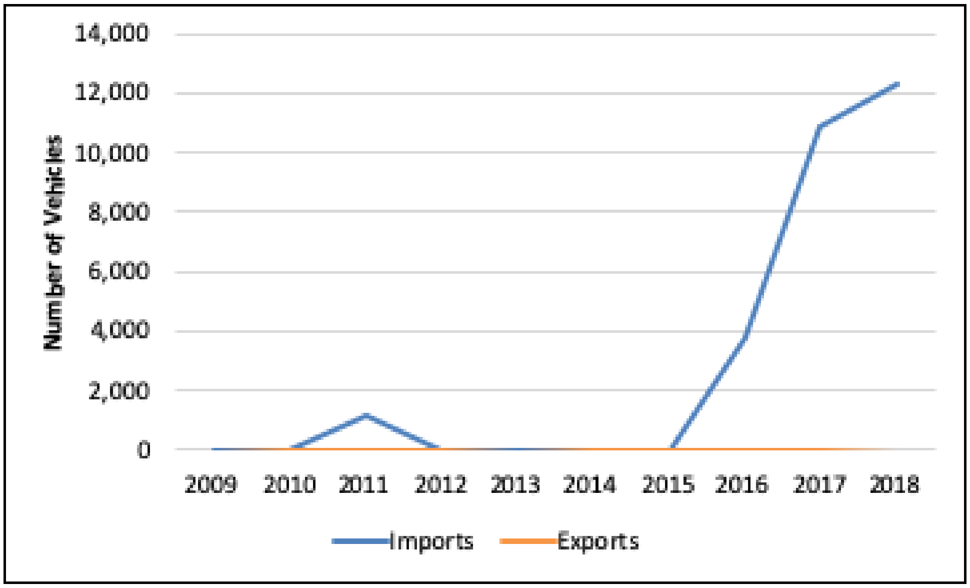


Exhibit 143: Passenger Vehicle Imports and Exports

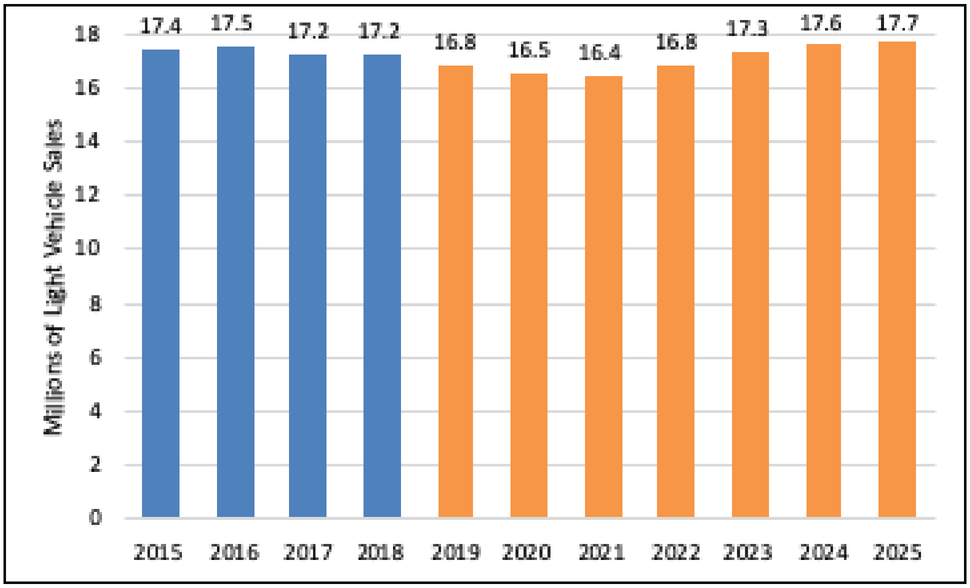
The compound annual growth rate between 2010 and 2018 was 9.5% for imports, 8.2% for exports, and 9.3% total.

Scenario Overview

Imports

Vehicles imported to the Bay Area are destined for dealerships throughout the nation and not just the local market; as such, the import forecast is driven by national growth and demand factors. The Center for Automotive Research (CAR) has forecast that light vehicle sales will decrease in each of the three coming years before slow growth returns in 2022 Exhibit 144).

Exhibit 144: U.S. Light Vehicle Sales Forecast



While this forecast does not differentiate between passenger vehicles and larger sports utility vehicles and pickup trucks there has been a shift between the two classes over the past decade. The National Automobile Dealers Association (NADA) stated that in 2018 light trucks accounted for approximately 70% of sales compared to 30% for cars. In contrast, NADA noted that the split was almost balanced about a decade ago when light trucks accounted for 48% of sales with cars accounting for 52%. This shift has been less pronounced with import to the Bay Area due to the dominance of U.S. truck manufacturers. The increased share of pickup truck imports to the Bay Area over the past three years is anticipated to continue, however, and even if the number of vehicles imported were to remain unchanged over the next 30 years the transitions from light passenger vehicles to SUVs and pickup trucks would still impact space utilization.

The impact of shared vehicles is anticipated to be the primary impact to passenger vehicles sales over the coming 30 years, whether those vehicles are driver-driven or autonomous in nature. The degree to which the population will shift to alternative modes of ownership (such as trip-based fees or annual subscription-based models) is highly debated. McKinsey and Company has predicted that by 2030 10% of new cars would be shared vehicles, increasing to as many as 33% by 2050. They also have forecast that by 2030 half of passenger vehicles sold would be highly autonomous and about 15% would be fully autonomous. Deloitte has a more aggressive outlook that suggests that by 2040 just 10% of new vehicle sales in urban areas will be personally owned driver-driven vehicles, with over 70% of new sales falling into the category of shared autonomous vehicles.

Recent surveys also suggest there is an ongoing generational shift in attitudes to car ownership, although the pace of that shift is debated. For example, AAA's most recent driving survey showed a decrease in the percentage of those who "drive at least occasionally" in the 16-19, 20-24, and 25-34 age groups between 2014-15 and 2016-17. While the degree to which that shift is occurring and the reasons behind it are beyond the scope of this effort, the forecast assumes that there will be an impact on sales relative to population growth due to this transition.

The import forecast (Exhibit 145 does not attempt to predict the percentage of vehicle sales that will be autonomous and/or shared ownership, nor does it attempt to predict the pace of change in vehicle ownership levels. Instead it acknowledges that the impact of technology and the shifting nature of vehicle ownership will result in a slowing pace of vehicle imports over time relative to population growth.

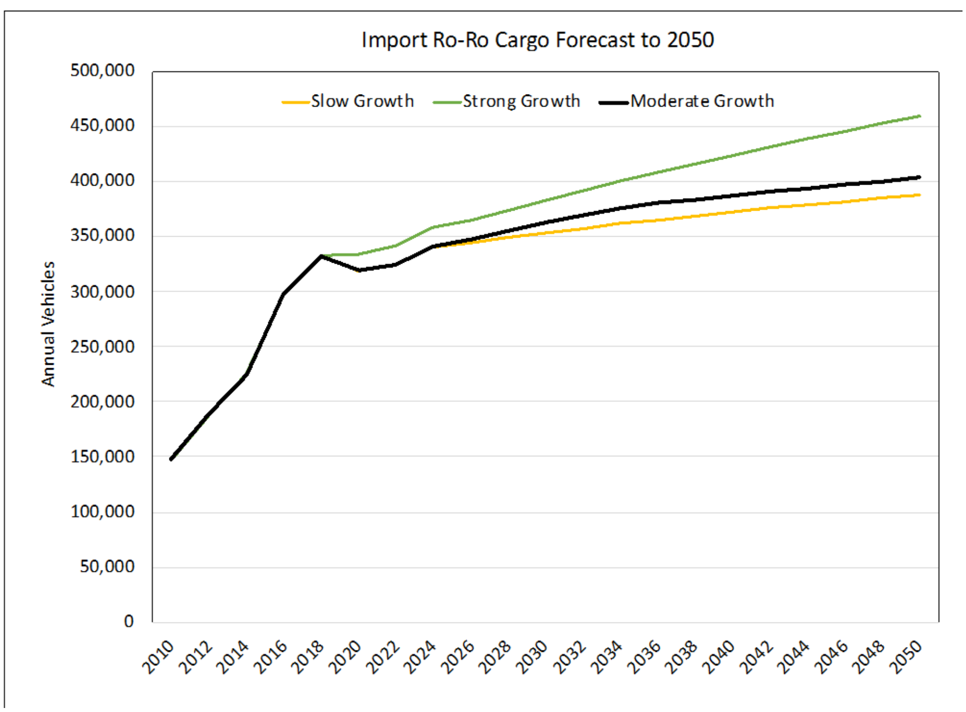
The Moderate Case import forecast is divided into the following eras:

- 2019-2021: Vehicle sales decrease due to a slowing economy and increased costs related to trade disputes.
- 2022-2025: Vehicle sales increase as the economy rebounds, with 2025 only slightly above the peak seen in 2016.
- 2026-2035: Vehicle sales increase at a slightly faster pace than population growth.
- 2036-2048: Vehicle sales increase but at a reduced pace in line with population growth as the transition to shared vehicles (autonomous or otherwise) becomes mainstream.

The low growth import forecast projects that vehicle sales under-perform the 2022-2025 CAR forecast and increase in line with population growth in both the 2026-2035 and 2036-2048 eras. The high growth import forecast projects that vehicle sales outperform the 2019-2021 CAR forecast and increase at a faster pace than population growth in both the 2026-2035 and 2036-2048 eras.

The compound annual growth rate between 2019 and 2048 is projected to be 0.7% in the Moderate Case scenario, 0.1% in the low growth scenario, and 1.1% in the high growth scenario.

Exhibit 145: Projected Vehicle Imports to the Bay Area by Scenario



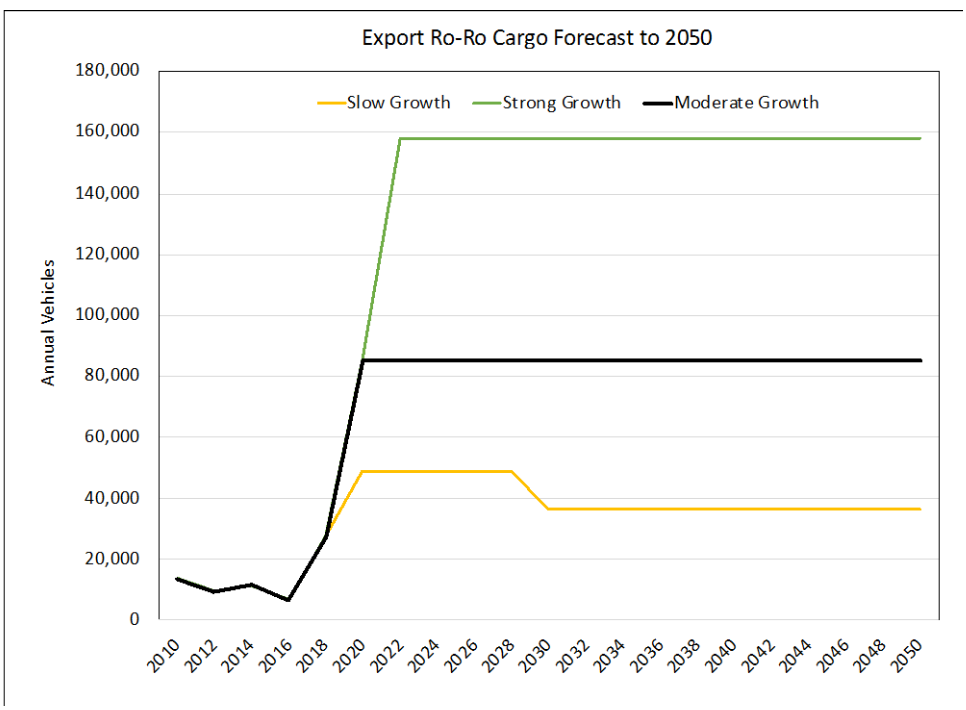
Exports

The exports forecast for the Bay Area is driven primarily by projected Tesla volumes, which makes projecting future export numbers highly speculative. At present the only facility producing Tesla models is located in Fremont, although work has commenced on a second factory in China. While this second facility would reduce the demand for Tesla models in that country it is assumed that there is plenty of demand in the rest of the world. It was reported that Tesla hoped to export 3,000 vehicles a week to Europe from February 2019 on. The current capacity at Fremont is supposedly 300,000 vehicles per year, although Tesla has stated that capacity will reach 500,000 vehicles per year. The new factory in China also has a capacity of 500,000 vehicles per year when it reaches full output. Although no further facilities have been announced, it stands to reason that Tesla will build additional factories should sufficient demand exist. The three growth scenarios assume that Tesla opens additional manufacturing facilities to serve overseas markets in ten years' time, thereby capping export volumes.

Vehicle exports will rely on ro-ro vessels for transportation. The first vessels to carry Tesla Model 3s to Europe in the first quarter of 2019 supposedly moved 1,400 vehicles per voyage. The three growth scenarios are in part constrained by the number of sailings per week that Tesla utilizes.

Exhibit 146 compares the three export forecasts for ro-ro cargo. The Moderate Case export scenario is based on the assumption that Tesla exports sufficient vehicles to satisfy a weekly call (with 1,400 vessels per call). The low growth export forecast projects that Tesla will utilize a bi-weekly service through 2028, after which the service decreases to once every three weeks. The high growth export forecast projects that Tesla will ramp up to a twice-weekly service starting in 2022. The compound annual growth rate between 2019 and 2048 is projected to be 1.9% in the Moderate Case scenario, -1.0% in the low growth scenario, and 4.1% in the high growth scenario.

Exhibit 146: Projected Vehicle Exports from the Bay Area by Scenario, 2000-2048



Total Ro-Ro Activity

Exhibit 147 compares the three growth forecasts for ro-ro cargo comprised of the base import/base export, low import/low export, and high import/high export scenarios. Exhibit 148 details these volumes in select years. The compound annual growth rate between 2019 and 2048 is projected to be 1.0 % in the Moderate Case scenario, 0.5% in the low growth scenario, and 1.8% in the high growth scenario.

Exhibit 147: Chart of Projected Total Ro-Ro Counts in the Bay Area by Scenario, 2000-2048

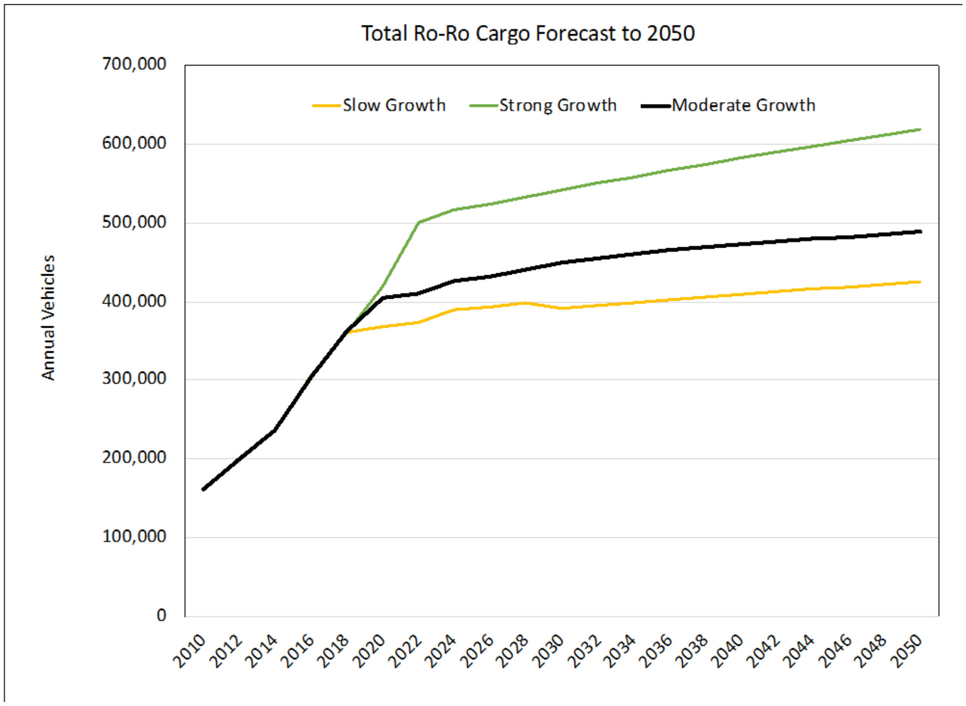


Exhibit 148: Projected Total Ro-Ro Activity in the Bay Area by Scenario

Scenario	2018	2022	2026	2030	2034	2038	2042	2048	CAGR
Low Case Vehicles	360,671	374,017	393,725	390,388	398,499	405,866	412,587	421,873	0.5%
Base Case Vehicles	360,671	410,417	432,324	448,696	460,885	469,291	476,108	485,629	1.0%
High Case Vehicles	360,671	500,114	523,159	541,505	558,722	574,689	589,577	610,811	1.8%

Ro-Ro Terminal Capacity

Ro-Ro terminals are a mix - most include a full range of functions on-site (e.g. Richmond), but others are part of a multi-site complex (e.g. Benicia). The consultant team's analysis assumes that existing organizational patterns will continue, and that future terminal space requirements are a function of volume growth.

Estimating the terminal space required to handle the auto and truck volumes shown above requires constructing scenarios for vehicle mix and dwell time, and then tracing the implications for terminal space.

Vehicle Size Mix

Average vehicle size has been growing with the popularity of SUVs, trucks, and especially double-cab trucks. The most recent data indicates that around 70% of new vehicles sold in the U.S. are trucks, primarily pickup trucks. The 10 largest-selling vehicles in the U.S. in 2018 were:

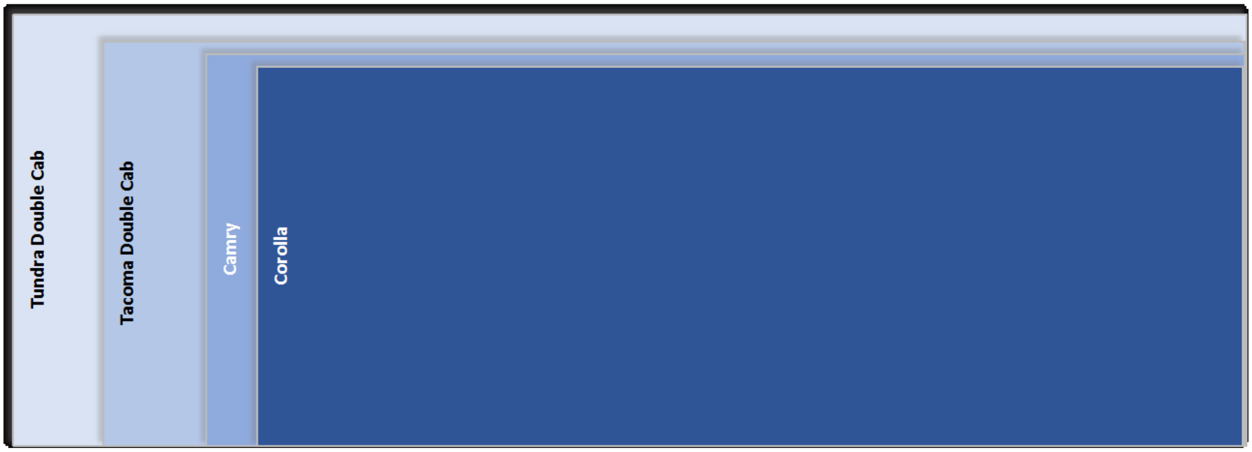
1. Ford F-Series pickup – 909,330
2. Chevrolet Silverado pickup – 585,581
3. Dodge Ram pickup – 536.980
4. Toyota RAV4 compact SUV – 427,170
5. Nissan Rogue compact SUV – 412,110
6. Honda CRV compact SUV – 397,813
7. Toyota Camry mid-size auto – 343,439
8. Chevrolet Equinox compact SUV – 332,618
9. Honda Civic compact auto – 325,760
10. Toyota Corolla compact auto – 303,732

Using familiar Toyota models as examples, Exhibit 149 shows the "footprint" of various types in square feet. The differences are illustrated in Exhibit 150. Exhibit 149 also shows Tesla models for comparison, and because Teslas are the dominant export brand.

Exhibit 149: Sizes of Selected 2019 Toyota and Tesla Models

Model	Size			Estimated Units per Acre
	Length Inches	Width Inches	Area SF	
Corolla	182.5	70.1	88.8	1849
RAV4	180.9	73.0	91.7	1578
Camry	192.7	72.2	96.6	1700
Tacoma Double Cab	212.3	74.4	109.7	1497
Sequoia	205.1	79.9	113.8	1443
Tundra Double Cab	228.9	79.9	127.0	1293
Tesla Model 3	184.8	76.1	97.7	1682
Tesla Model S	196	77.3	105.2	1561
Tesla Model X	198.3	81.5	112.2	1463

Exhibit 150: Vehicle Space Needs Comparison



Under the assumption that the "mid-size" sedan (Camry) in Exhibit 149 reflects the current average vehicle size at the average throughput of 1,700 per acre, Exhibit 149 also shows the impact of vehicle size on throughput. As larger vehicles enter the mix, throughput per acre drops. A shift toward smaller vehicles, particularly small urban "robo-taxis" envisioned by some observers, would increase throughput per acre.

Productivity Scenarios

Exhibit 151 combines variations in dwell time and vehicle mix to develop Moderate Case, low, and high productivity scenarios for ro-ro terminal space. The numbers used in Exhibit 151 are not intended to reflect the current experience or performance of specific terminals or operators, but to illustrate the range of outcomes from variations in dwell time and vehicle size mix.

Shifting the mix toward more trucks (or large SUVs) and increasing dwell time would both reduce working throughput. The volumes shown would reduce annual average vehicles per acre by about 24%. Factors in such a shift could include:

- Increased production of trucks and large SUVs in foreign countries (i.e. the current production of double-cab Tacomas in Mexico).
- Popularity of mid-size rather than compact vehicles in shared-ride applications (a Tesla 3 is 185" long and 73" wide, closer to a mid-size Camry than a compact Corolla).
- Low gas prices, favoring larger cars.
- Import and export strategies favoring more processing at the port and favoring truck delivery over rail.

Shifting the mix toward more compact cars or compact SUVs and reducing average dwell time from 15 to 12 days could reduce occupancy and space requirements by about 22 percent, and increase annual throughput per acre. Factors in such a shift could include:

- Concentration of future truck and large SUV production in the U.S.
- Increased popularity of compact electric cars and SUVs, and use of compact vehicles in ride-sharing.
- Rising fuel prices.
- Import strategies favoring minimal processing at the port and a maximum use of rail.

Exhibit 151: Ro-Ro Productivity Scenarios

Case	Average Dwell Days	Unit Size Distribution - Square feet Compact 88.8	Mid-Size 96.6	Truck 109.7	Average	Occupancy Index	% Change	Annual Units per Acre
Low Productivity	18	25%	50%	25%	97.9	1,763	24%	1,371
Base Case	15	40%	50%	10%	94.8	1,422	na	1,700
High Productivity	12	50%	50%	0%	92.7	1,113	-22%	2,173

The shifts contemplated in Exhibit 151 are likely to take place over several years rather than all at once. Exhibit 152 spreads the changes out over 10 years to provide a plausible progression of ro-ro terminal productivity.

Exhibit 152: Ro-Ro Productivity Shifts to 2030

Scenario	2018	2020	2022	2024	2026	2028	2030
Low Productivty Units/Acre	1,700	1,640	1,583	1,527	1,473	1,421	1,371
Base Productivty Units/Acre	1,700	1,700	1,700	1,700	1,700	1,700	1,700
High Productivty Units/Acre	1,700	1,771	1,845	1,922	2,002	2,086	2,173

Ro-Ro Terminal Needs

The chart in Exhibit 153 and the table in Exhibit 154 display the combined ro-ro forecast and capacity analysis. Nine scenario combinations are presented. Productivity is held constant after the 10-year phase-in shown in Exhibit 152.

- The Moderate Case forecast and Moderate Case productivity scenario together suggest that 286 acres of ro-ro terminal space would be required to handle 485,629 vehicles in 2048.
- At the lower extreme, the Slow Case forecast and the high productivity scenario together call for 194 acres to handle 421,873 vehicles in 2048.
- The high forecast and low productivity scenario together require 445 acres to handle 610,881 vehicles in 2048.

As both the table and the chart indicate the scenario combinations overlap. The combination of a high forecast and high productivity, for example, would require 281 acres versus 286 acres for the base/base combination.

Exhibit 153: Ro-Ro Terminal Acreage Requirements to 2050

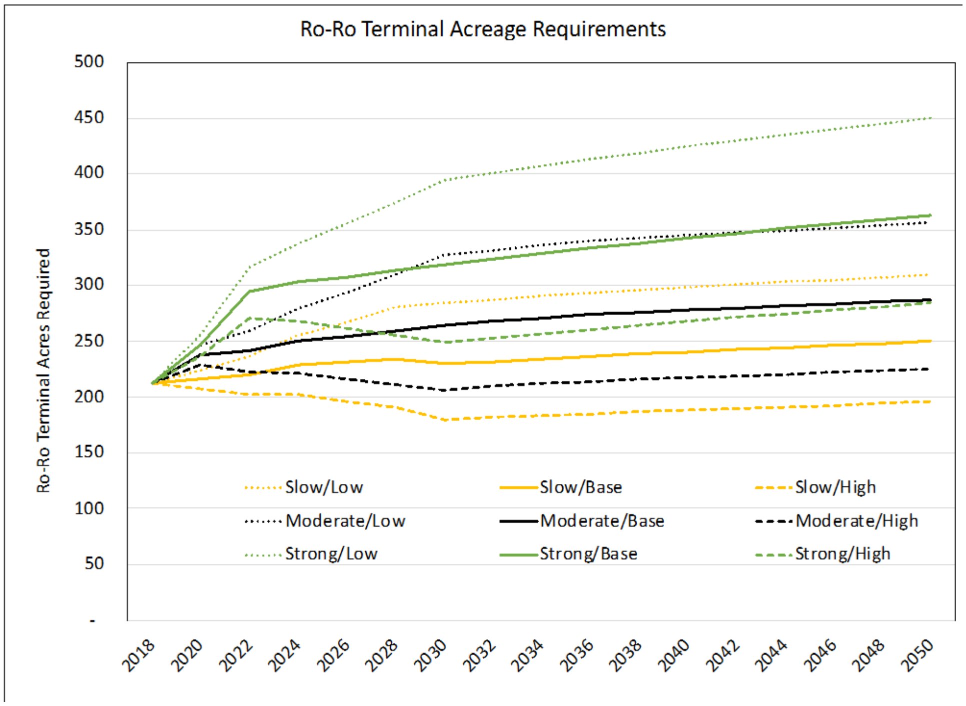


Exhibit 140: Ro-ro Cargo Summary

Scenario		2018	2020	2022	2024	2026	2028	2030	2032	2034	2036	2038	2040	2042	2044	2046	2048	2050	Existing Acres	New Acres	CAGR
Slow Growth		360,671	368,207	374,017	389,512	393,725	398,197	390,388	394,537	398,499	402,271	405,866	409,298	412,587	415,757	418,841	421,873	424,892			0.5%
Low Prod. Acres	L/L	212	224	236	255	267	280	285	288	291	293	296	298	301	303	305	308	310	215	95	1.2%
Base Prod. Acres	L/B	212	217	220	229	232	234	230	232	234	237	239	241	243	245	246	248	250	215	35	0.5%
High Prod. Acres	L/H	212	208	203	203	197	191	180	182	183	185	187	188	190	191	193	194	196	215	(19)	-0.3%
Moderate Growth		360,671	404,607	410,417	425,912	432,324	441,154	448,696	454,920	460,885	465,655	469,291	472,768	476,108	479,342	482,504	485,629	488,768			1.0%
Low Prod. Acres	B/L	212	247	259	279	293	310	327	332	336	340	342	345	347	350	352	354	356	215	141	1.6%
Base Prod. Acres	B/B	212	238	241	251	254	260	264	268	271	274	276	278	280	282	284	286	288	215	73	1.0%
High Prod. Acres	B/H	212	228	222	222	216	212	207	209	212	214	216	218	219	221	222	224	225	215	10	0.2%
Strong Growth		360,671	418,831	500,114	516,414	523,159	532,448	541,505	550,273	558,722	566,855	574,689	582,249	589,577	596,731	603,784	610,811	617,923			1.7%
Low Prod. Acres	H/L	212	255	316	338	355	375	395	401	407	413	419	425	430	435	440	445	451	215	236	2.4%
Base Prod. Acres	H/B	212	246	294	304	308	313	319	324	329	333	338	342	347	351	355	359	363	215	148	1.7%
High Prod. Acres	H/H	212	236	271	269	261	255	249	253	257	261	264	268	271	275	278	281	284	215	69	0.9%

Exhibit 155 shows that existing ro-ro terminals total about 215 acres, which compares closely to the estimate of 212 acres required under the base/Moderate Case in Exhibit 154. This comparison is also consistent with the observations by port officials that the Richmond and Benicia terminals are operating at or near capacity at present.

Exhibit 155: Bay Area Ro-Ro Terminals and Scenario Capacities

Terminal	Acres	Low Capacity	Base Case Capacity	High Capacity
Annual Units per Acre		**1,371**	**1,700**	**2,173**
Existing	215	294,859	365,500	467,146
Benicia	75	102,858	127,500	162,958
Richmond Pt. Potrero	80	109,715	136,000	173,822
SF Pier 80	60	82,286	102,000	130,366
Potential	103	141,258	175,100	223,795
SF Pier 96	53	72,686	90,100	115,157
Oakland Howard Terminal	50	68,572	85,000	108,639
Total	**318**	**436,117**	**540,600**	**690,941**

Ro-Ro Cargo Capacity Findings

Based on the consultant team's analysis, additional ro-ro terminal space will be required to accommodate any of the forecast scenarios. The most acreage would be required for higher growth and lower productivity, as expected. The Moderate Case capacity for the existing 215 acres is estimated at 365,500 annual units, very close to the 360,671 units reported for 2018 (Exhibit 154). At the higher productivity of 2,173 units per acre the existing terminals could handle an estimated 467,146 annual units, nearly enough for the Moderate Case forecast in Exhibit 154. If productivity declines, the existing terminals could fall short of even the low-growth forecast requirements.

A typical ro-ro auto carrier vessel, such as the Glovis Condor, which called at Benicia in early 2019 (Exhibit 156), is about 650 feet long and 105 feet wide, with a design draft of 40 feet and a typical sailing draft of about 32 feet. Fully loaded, such a vessel would require 43 feet of draft (with 3 feet of under keel clearance), and as typically loaded would require about 35 feet.

Exhibit 156: Glovis Condor Ro-Ro Vessel

Within the Bay Area, the larger unused marine terminal spaces suitable for ro-ro operations (either as-is or with minor improvements) are Pier 96 at San Francisco and Howard Terminal at Oakland.

Pier 96. The Pier 96 site at San Francisco is roughly 53 acres at a former container terminal. The site appears to have 9 acres of usable wharf face and is paved, with several structures that may or may not be usable for auto processing. Pier 96 has on-dock rail trackage and access to additional rail facilities at a nearby site originally intended for intermodal operations. Recent NOAA charts show a 39-foot nominal draft at Pier 96, sufficient for typical ro-ro auto carrier vessels.

Howard Terminal. Howard Terminal is a dormant container terminal of about 50 acres on the Oakland Estuary. The terminal is paved and appears to have a usable wharf face for ro-ro operations. Recent NOAA charts show a nominal 42-foot draft for Howard Terminal, sufficient for most ro-ro auto carriers. Howard has potential access for on-dock rail, and is roughly one mile from the UP or BNSF intermodal facilities at Oakland.

Pittsburg Site. The Amports site at Pittsburg , outside of the Bay, is roughly 110 acres. The existing pier and wharf have a nominal draft of about 35 feet, which would likely require dredging to accommodate loaded ro-ro vessels. This facility is not yet fully operational, and will not necessarily be used to handle imports and exports, as Amports also handles domestic vehicles.

VI. Bay Area Dry Bulk Cargo Forecast and Capacity Analysis

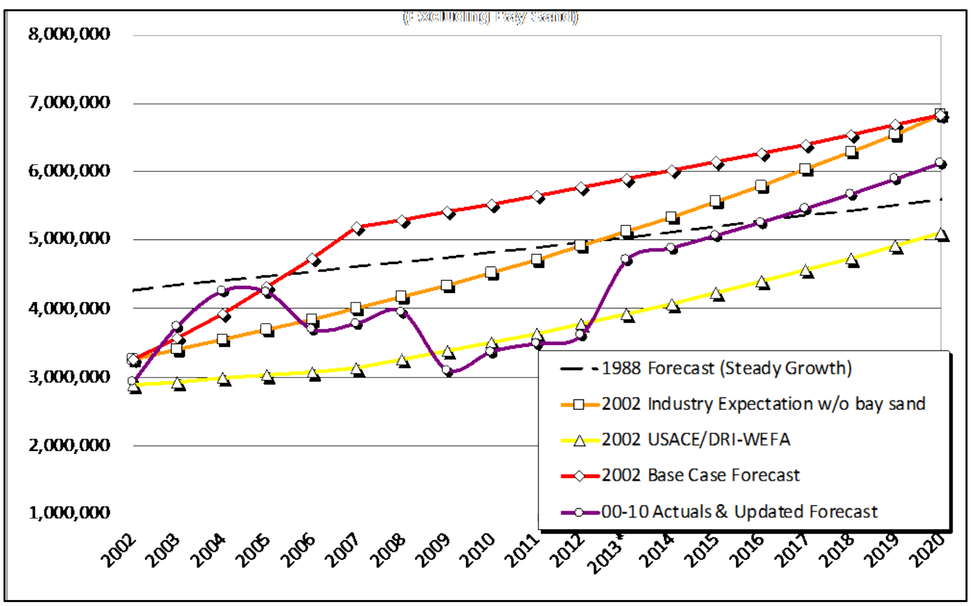
Dry Bulk Cargo Review

The Bay Area ports handle a variety of bulk cargo, including:

- Import sand and gravel at Redwood City and San Francisco
- Harvested Bay sand at Redwood City and San Francisco
- Import bauxite and slag at Redwood City
- Import gypsum at Richmond and Redwood City
- Export scrap metal at Redwood City , Richmond, and Schnitzer Steel in Oakland Harbor
- Export petroleum coke at Benicia and Levin Richmond Terminal
- Export coal at Levin Richmond Terminal

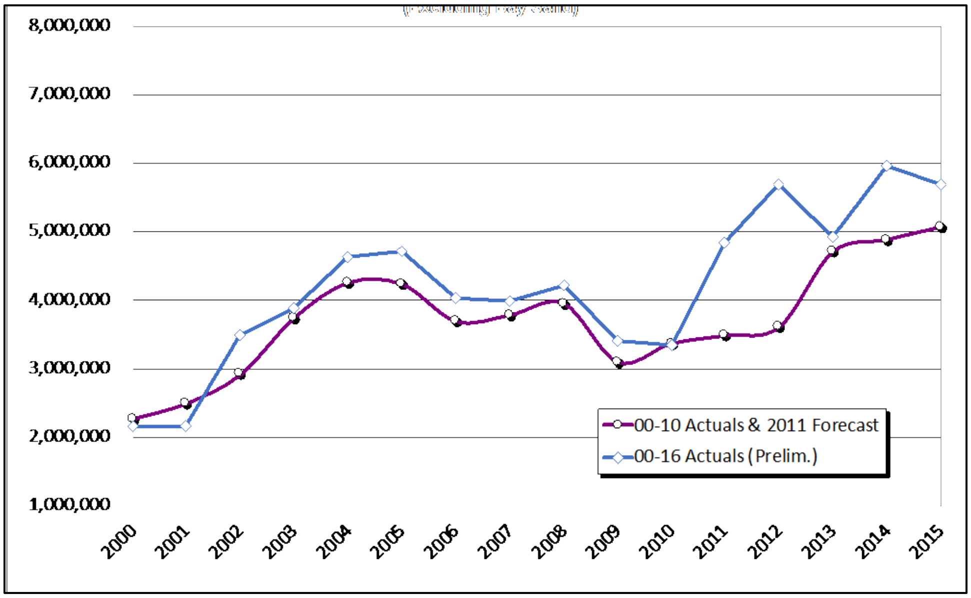
The dry bulk import cargoes handled through Bay Area ports have long been dominated by construction industry needs. The major commodities have included, and continue to include, aggregates (sand and gravel), bauxite and slag (used as concrete additives), and gypsum (used in wallboard). Outbound dry bulk cargoes include scrap metal, petroleum coke (pet coke, a refinery by-product), and coal. Exhibit 157 shows the 2011 forecast.

Exhibit 157: 2011 Dry Bulk Forecast



As Exhibit 158 shows, dry bulk cargo volumes have varied from the 2011 forecast as economic development and construction activity have varied. The 2011 forecast anticipated increased imports of aggregates as Northern California production declined. The consultant team will revisit this issue in developing a new forecast.

Exhibit 158: 2011 Dry Bulk Forecast vs. Actuals, 2000-2016



The 2011-2016 actuals also reflect substantial iron ore shipments through Levin Richmond Terminal in 2011-2013, and coal shipments in 2013-2016.

There is limited competition between regional ports for bulk commodity exports. The Port of Stockton and Levin Richmond Terminals have handled export coal and iron ore movements, primarily from Utah to China. These movements might have been handled through the bulk export terminal at the Port of Long Beach.

Exhibit 159 shows recent volumes and growth.

Exhibit 159: Bay Area Dry Bulk Cargo

Commodity	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018 Est.	CAGR
Bay Sand	1,053,558	718,931	725,711	604,139	500,847	326,807	492,042	852,626	914,752	1,006,707	-0.3%
Import Sand	76,248	44,586	280,680	145,909	328,249	179,544	448,480	822,230	792,497	1,320,834	17.2%
Import Aggregates	-	727,128	985,252	903,641	934,071	859,993	1,701,573	1,655,774	1,240,155	1,435,703	18.2%
Sand & Gravel Subtotal	**1,129,806**	**1,490,645**	**1,991,643**	**1,653,689**	**1,763,167**	**1,366,344**	**2,642,095**	**3,330,630**	**2,947,404**	**3,763,244**	**6.9%**
Import Gypsum	231,393	230,711	301,653	294,833	189,710	159,301	198,202	180,501	108,166	380,820	2.8%
Import Bauxite & Slag	154	14,496	91,765	83,551	72,881	53,348	74,992	92,675	53,410	145,437	46.3%
Imports	**1,361,353**	**1,735,852**	**2,385,061**	**2,032,073**	**2,025,758**	**1,578,993**	**2,915,290**	**3,603,806**	**3,108,980**	**4,289,501**	**6.6%**
Export Scrap	1,473,600	1,433,219	1,976,601	1,766,486	2,241,777	3,060,480	3,632,256	2,654,650	2,481,437	2,506,842	3.0%
Export Pet Coke	306,156	450,929	315,325	298,536	363,435	327,976	646,868	603,860	599,253	562,112	3.4%
Export Coal	-	-	-	-	-	-	-	1,142,035	419,605	999,061	25.8%
Exports	**1,779,756**	**1,884,148**	**2,291,926**	**2,065,022**	**2,605,213**	**3,388,456**	**4,279,125**	**4,400,546**	**3,500,296**	**4,068,015**	**4.7%**
Total Dry Bulk	**3,141,109**	**3,620,000**	**4,676,987**	**4,097,095**	**4,630,971**	**4,967,449**	**7,194,414**	**8,004,352**	**6,609,276**	**8,357,516**	**5.6%**

All of the dry bulk imports are tied to the construction industry. Sand and gravel have multiple uses, as well as being components of concrete. Cement, bauxite, and slag are all used in concrete. Gypsum is primarily used in manufacturing drywall (e.g. Sheetrock).

Forecast Commodity Flows

The different commodities require different approaches to a forecast.

Sand & Gravel (Aggregates)

Aggregate import volumes are determined by demand and local supply. The 2009 forecast update noted that Northern California production of aggregates was not keeping up with growing demand:

- Northern California quarries were being depleted or could not expand.
- Environmental and community concerns severely restrict new production sites.
- Import sources in British Columbia and elsewhere could compete effectively with domestic sources outside of Northern California.
- Northern California supply of specific aggregate types used in high grade concrete for infrastructure projects was particularly tight.

A 2018 study by the California Geological Survey found that the state's permitted aggregate resources increased by 88% between 2011 and 2017. As Exhibit 160 indicates, California has only about 69% of the aggregate resources need to meet demand over the next 50 years. Most areas served by the Bay Area ports have an 21-30 year supply, suggesting that the need for imported aggregates will rise sharply in that timeframe.

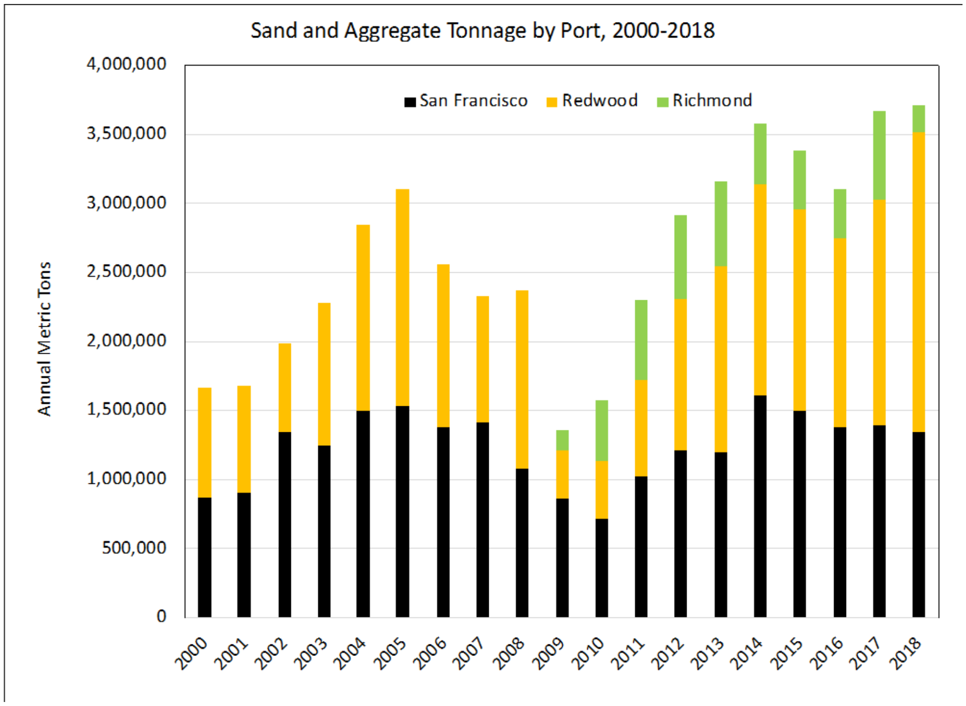
Exhibit 160: Department of Conservation - California Geological Survey's 50-year Aggregate Supply Outlook as of January 1, 2017

AGGREGATE STUDY AREA[1]	50-Year Demand (million tons)	Permitted Aggregate Reserves (million tons)	Permitted Aggregate Reserves Compared to 50-Year Demand (percent)	Projected Years Remaining
Bakersfield P-C Region	338	1,708	505	More than 50
Barstow-Victorville P-C Region	163	117	72	31 to 40
Claremont-Upland P-C Region	202	90	45	21 to 30
El Dorado County	82	15	18	11 to 20
Fresno P-C Region	305	556	182	More than 50
Glenn County	41	22	54	21 to 30
Merced County	154	61	40	21 to 30
Monterey Bay P-C Region	333	297	89	41 to 50
Nevada County	41	52	127	More than 50
North San Francisco Bay P-C Region	492	263	53	21 to 30
Palmdale P-C Region	569	163	29	11 to 20
Palm Springs P-C Region	238	163	68	31 to 40
Placer County	188	387	206	More than 50
Sacramento County	724	327	45	21 to 30
Sacramento-Fairfield P-C Region	295	109	37	21 to 30
San Bernardino P-C Region	939	156	17	11 to 20
San Fernando Valley/ Saugus-Newhall[2]	**387**	**17**	**4**	**10 or fewer**
San Gabriel Valley P-C Region	751	297	40	21 to 30
San Luis Obispo-Santa Barbara P-C Region	226	58	26	11 to 20
Shasta County	82	49	60	31 to 40
South San Francisco Bay P-C Region	1,320	506	38	21 to 30
Stanislaus County	160	39	24	11 to 20
Stockton-Lodi P-C Region	409	203	50	21 to 30
Tehama County	49	30	61	31 to 40
Temescal Valley-Orange County[2]	1,079	862	80	41 to 50
Tulare County	130	53	41	21 to 30
Ventura County[2]	241	84	35	11 to 20
Western San Diego County P-C Region	763	265	35	11 to 20
Yuba City-Marysville P-C Region	344	679	197	More than 50
Total	11,045	7,628	69	

[1] Aggregate study areas follow either a Production-Consumption (P-C) region boundary or a county boundary. A P-C region includes one or more aggregate production districts and the market area that those districts serve. Aggregate resources are evaluated within the boundaries of the P-C Region. County studies evaluate all aggregate resources within the county boundary

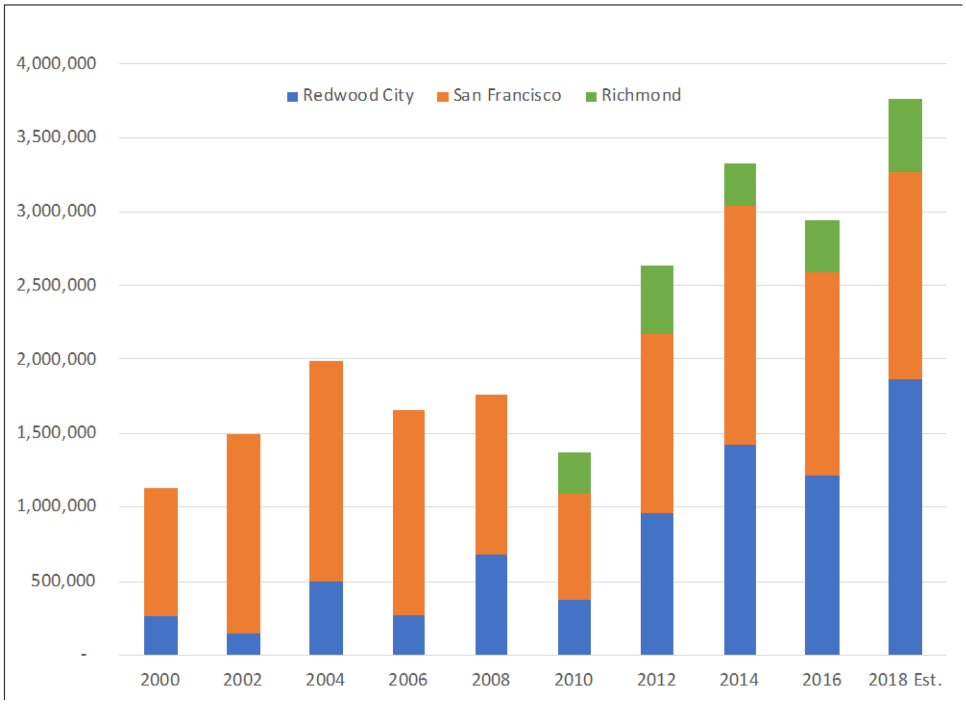
Exhibit 161 shows the recent history, with strong growth picking up after the recession.

Exhibit 161: Bay Area Sand and Gravel Tonnage, 2000-018



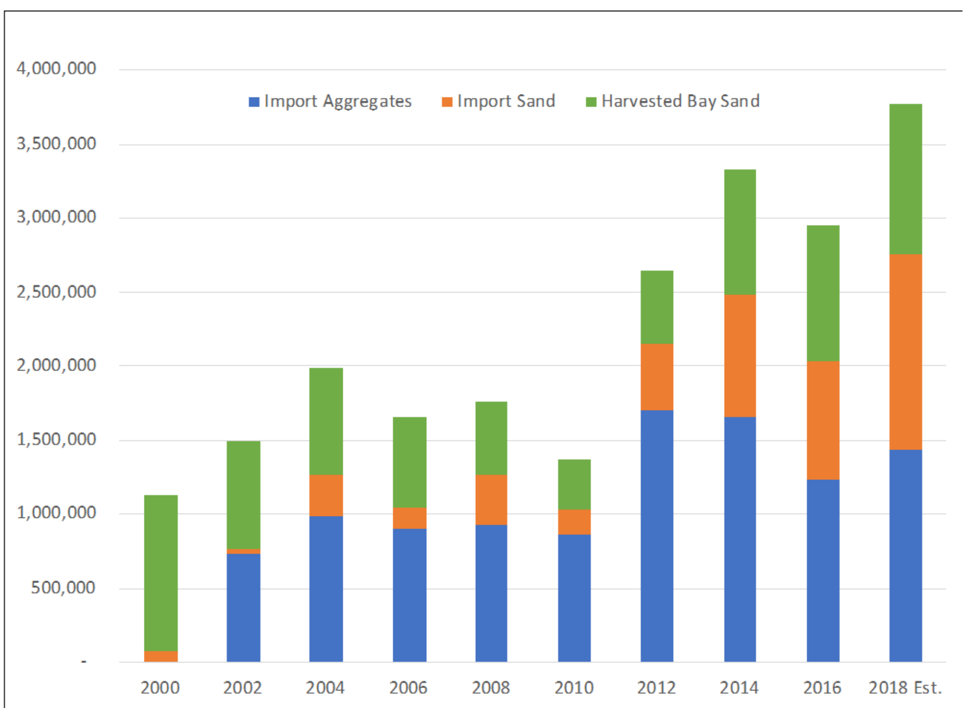
Much of the dry bulk cargo handled by the ports of Redwood City, Richmond, and San Francisco is related to the construction industry, including sand that is dredged from the bay floor. (Sand "harvested" from the Bay floor is not a cargo per se, but is included for land use planning purposes.) The data show the dominance of imported aggregate materials and sand, and bay sand in 2018 (including estimates), with 88% of the total imports. Gypsum accounted for 9% of the total ,and slag and bauxite together 3%. Cement and limestone have not been imported since 2009, at least in part because rail imports have taken their place.

Exhibit 162: Aggregate Imports + Bay Sand by Port, 2000-2018



Note: Richmond data begin in 2010.

Exhibit 163: Bay Area Aggregate Imports + Bay Sand by Commodity, 2000-2018



Note: Richmond data begin 2010.

Growth since 2010 showed an annual growth rate of 15.1% for aggregates and sand, 10.2% for bay sand, 11.5 % for gypsum, and 10.5% for bauxite. The rate of growth of imports of aggregates and sand and the handling of bay sand over the past five years was slower, with decreases of 2.3% annually and increases of 4.2% respectively. Gypsum meanwhile increased at an annual rate of 20.5% over the past five years.

The amount of construction-related dry bulk cargo delivered to the Bay Area ports is a factor of the construction needs of the region as well as the production capacity of regional and national mines.

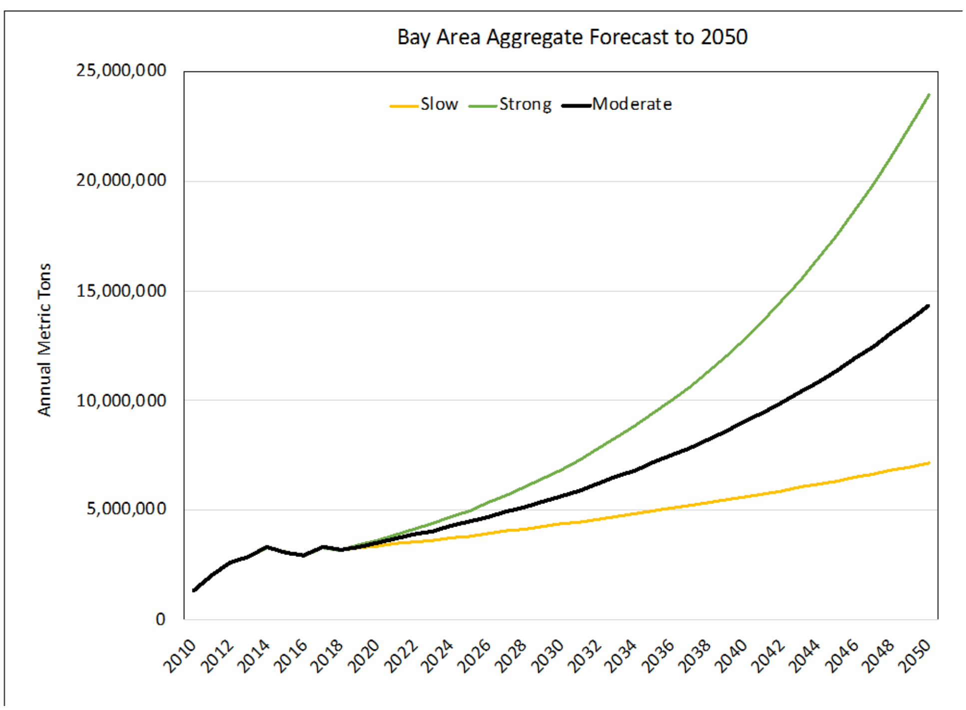
Research suggests that the rule of thumb for calculating aggregate demand (including sand and gravel) is to use a stable long-term per capita consumption per person. Demand growth was based on the population forecast for the nine-county Bay area. The Caltrans population projections were used to estimate demand growth out to 2048.

The consultant team did not attempt to distinguish demand for harvested bay sand from demand for import sand. Different grades and types of sand are produced locally, harvested from the bay, or imported for a wide variety of end uses that will change over time.

The forecast takes into account the reports that the State of California is facing a shortfall in permitted reserves of sand and gravel, although estimates regarding the extent of the remaining supply vary. In 2018 it is estimated that imported and harvested sand and gravel met 8.1% of the annual demand. The Moderate Case scenario assumes that due to mining limitations the share of imported and harvested sand and gravel will increase to 30% by 2050; the low growth scenario increases to 15% by 2050 and the high growth scenario reaches 50% by 2050.

Exhibit 31 shows the base, low growth and high growth scenario forecasts through 2050 for the import of aggregates and bay sand.

Exhibit 164: Bay Area Sand and Gravel Forecast, 2010-2050

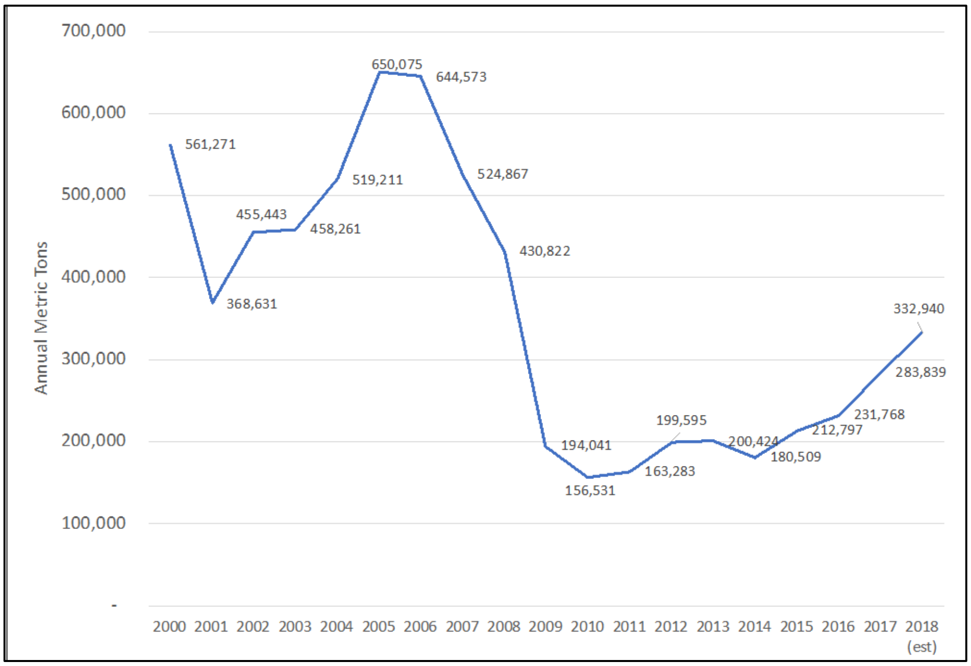


The compound annual growth rate for aggregates and bay sand between 2018 and 2050 is projected to be 4.7% in the Moderate Case scenario, 2.5% in the low growth scenario, and 6.4% in the high growth scenario.

Gypsum

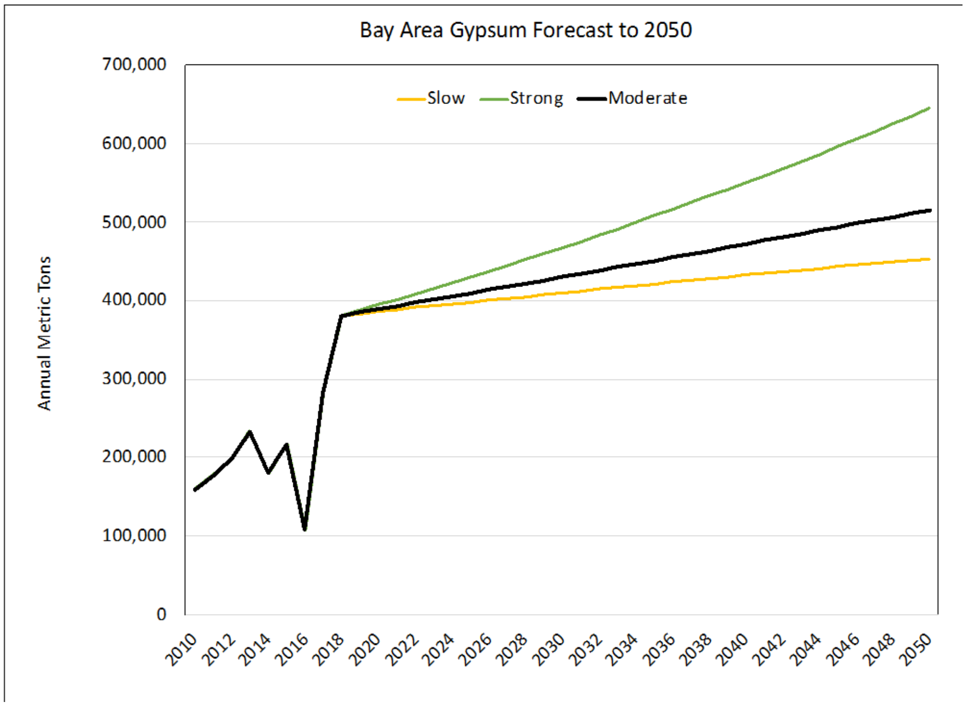
Bay Area Gypsum imports dropped off sharply during the recession and have grown gradually since (Exhibit 165). The U.S. as a whole remains the world's leading producer of gypsum, but imports have none the less grown. Part of U.S. demand is filled by synthetic gypsum derived from byproducts of coal-fired powerplants. This source is likely to diminish as coal-fired plants close and are replaced with natural gas powerplants, leading to a greater demand for imports.

Exhibit 165: Bay Area Gypsum Imports, 2000-2018



The amount of gypsum also tends to be a function of population. The gypsum forecast uses the same population growth factors for the nine-county area. In 2018 it is estimated that imported gypsum met 52.8% of the annual demand. The Moderate Case scenario assumes that the share of imported gypsum will increase to 60% by 2050; the low growth scenario remains at 52.8%, and the high growth scenario reaches 75% by 2050. The compound annual growth rate for gypsum imports between 2019 and 2050 is projected to be 1.0% in the Moderate Case scenario, 0.6% in the low growth scenario, and 1.7% in the high growth scenario. Exhibit 32 depicts the scenarios for gypsum imports through 2050.

Exhibit 166: Bay Area Import Gypsum Forecast, 2010-2050

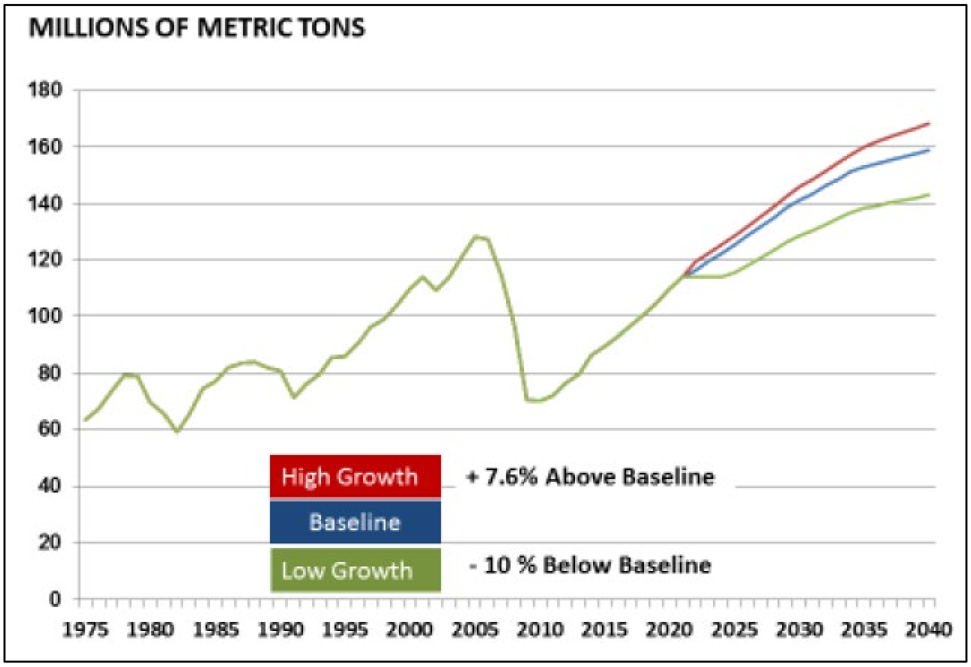


Bauxite & Slag

Bauxite and slag are imported for use in domestic cement production (some portion of the gypsum is used in cement production as well). The amount of bauxite and slag imported will vary with the amount of cement demanded and produced. The consultant team assumed that the current volume of bauxite and slag imported reflects the share of cement demand being filled by domestic production, and did not alter that implicit share. Bauxite and slag imports will therefore grow with cement consumption regardless of the cement source.

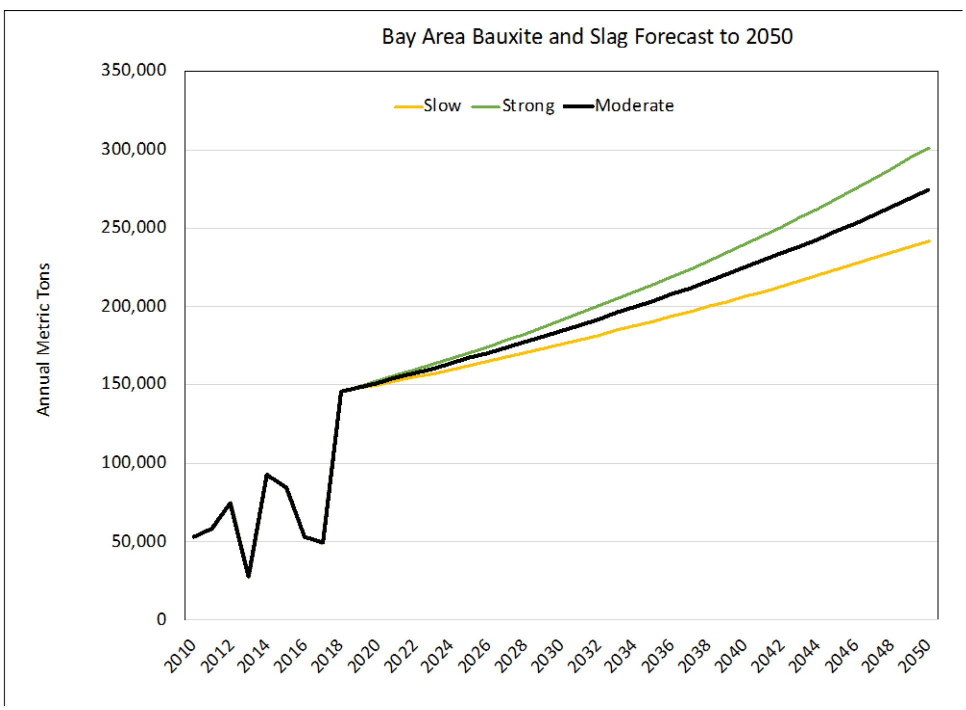
The Portland Cement Association (PCA) found that per capita cement consumption rises with GDP. A 1% increase in GDP growth yields a 0.7% increase in per capita consumption. Accounting for both rising GDP and rising per capita consumption, PCA sees cement consumption rising at a CAGR of 2.0% from 2018 to 2040 (Exhibit 167) for a base case forecast. The low growth forecast was for 1.6% CAGR, and 2.3% for the high growth case.

Exhibit 167: PCA Cement Consumption Forecast



These growth rates were applied to Bay Area bauxite and slag imports (Exhibit 168), and would likely apply to cement and limestone imports if and when they resume.

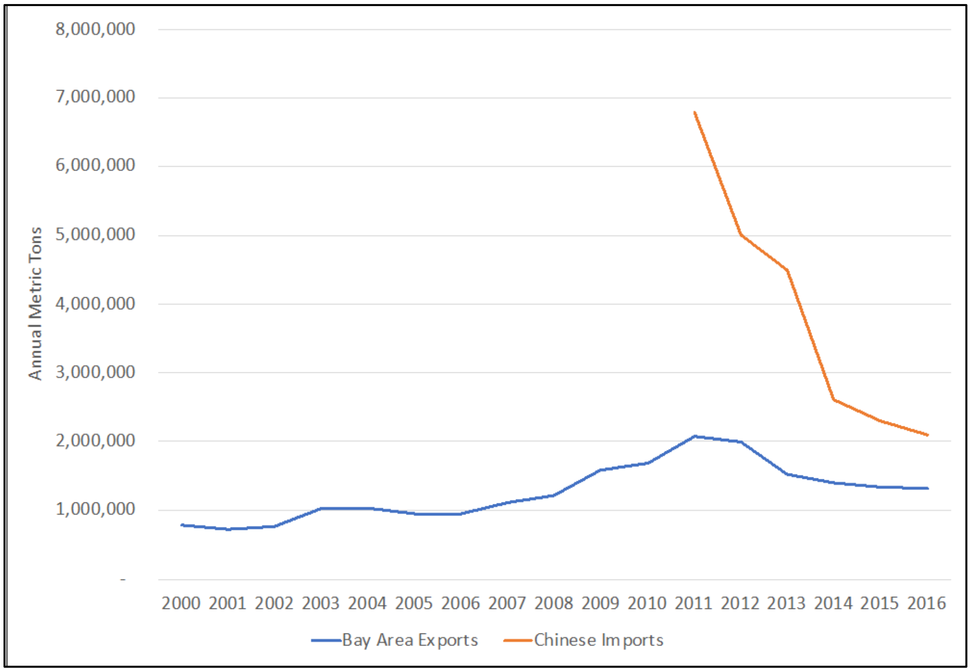
Exhibit 168: Bay Area Bauxite & Slag Import Forecast, 2010-2050



Scrap metal

Bay Area scrap metal exports peaked in 2011 and have fallen since, largely due to changes in world market conditions. Exhibit 169 shows that the decline in Bay Area exports starting in 2011 coincides with the decline in Chinese imports.

Exhibit 169: Bay Area Export Scrap Metal, 2000-2016 [2017-2018 data pending]



China has been the largest customer for U.S. scrap exports, but is buying less for two reasons:

- Tighter controls on the quality and purity of imported scrap.
- Greater domestic "production" of scrap metals.

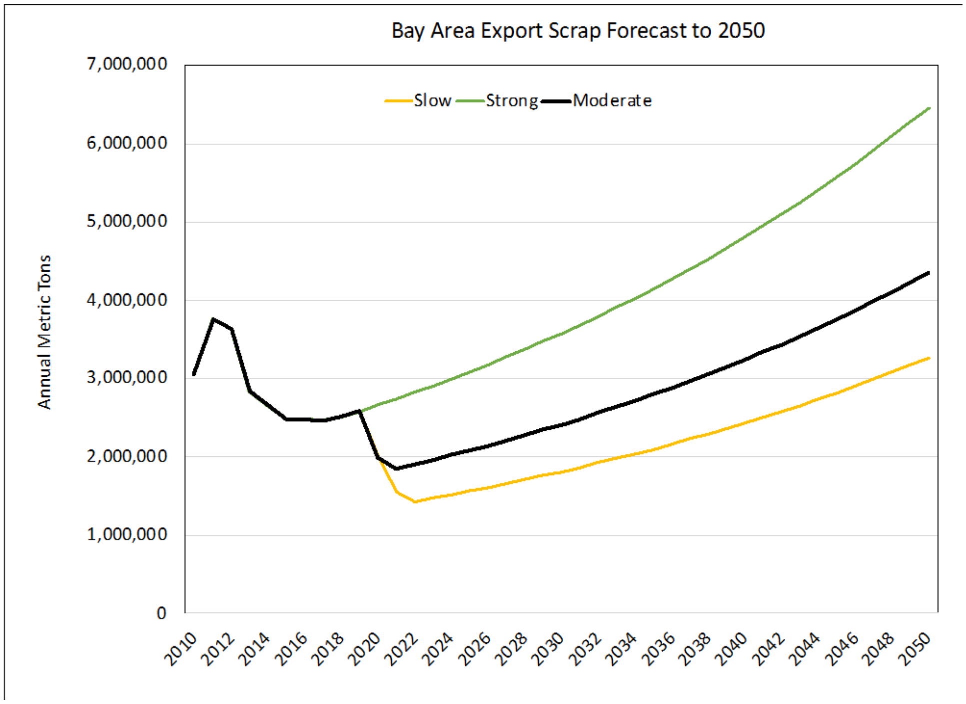
The administration's proposed tariffs on imported metals will likely increase U.S. consumption of scrap as well, leaving less to export.

The outlook for export scrap metal is uncertain, due in part to impending closure or drastic reduction in the Chinese imports. Recent Bay Area export growth has averaged about 3.0%, and industry sources call for continued growth at similar rates. Long-term, a 3.0% CAGR was used for the scrap metal forecast (Exhibit 170).

China has been the main foreign market for West Coast scrap metal exports. China has placed strict requirements on imports of waste and recycled materials, and has announced intentions to ban such imports after 2020. Overall growth is expected in the global market for ferrous and non-ferrous scrap metals, as the use of recycled metals is generally more efficient than producing metals from original ores.

Loss of the Chinese market is included in both the Moderate Case and low growth scrap metal scenarios. The Moderate Case allows for more rapid recovery, i.e. selling to different foreign markets, than the Slow Case. The Strong Case allows for continuation of recent growth assuming either that a portion of the Chinese market is retained or that the Chinese demand is replaced seamlessly with demand from other nations. As a result of the short-term adjustments, the compound annual growth rate for scrap metal exports between 2019 and 2050 is projected to be 1.7% in the Moderate Case scenario, 0.8% in the low growth scenario, and 3.0% in the high growth scenario.

Exhibit 170: Bay Area Export Scrap Metal Forecast, 2010-2050

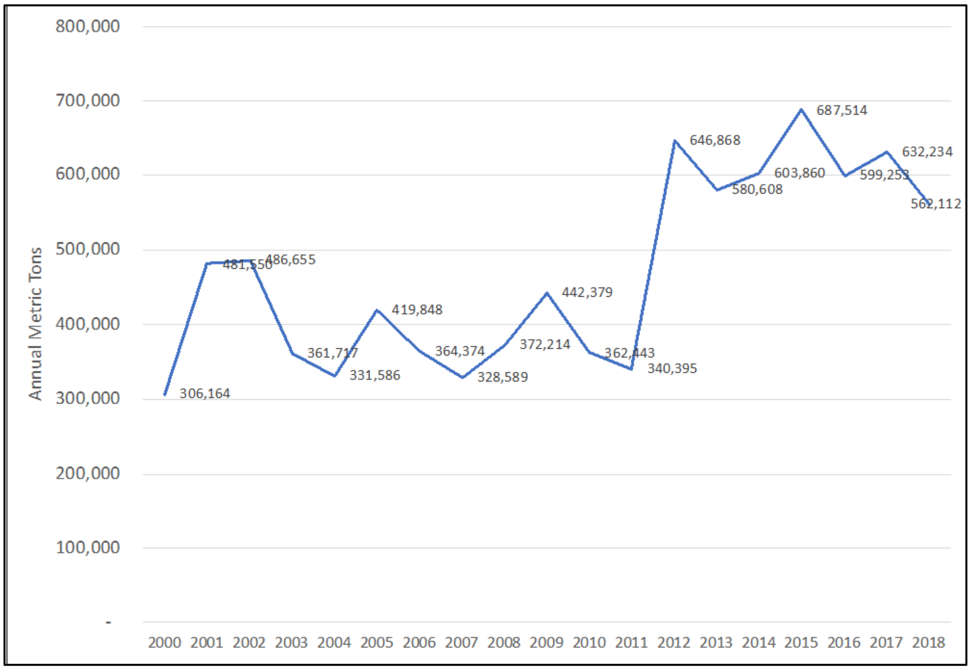


Petroleum Coke

Petroleum coke (pet coke) is a by-product of petroleum refining, and Bay Area production of pet coke is therefore driven by refinery activity. Pet coke is used as a fuel for energy production, and some grades are also used in steelmaking and chemical production. Demand for pet coke is largely foreign. As of 2013 the U.S. was exporting about 80% of the pet coke produced; essentially all of the Bay Area production is exported through Benicia or Levin Richmond. Due to heightened environmental concerns, there is strong community pressure to stop pet coke exports from Levin Richmond.

Exhibit 171 shows pet coke exports since 2000. The volume increased noticeably in 2011-2012 after the recession, but has remained relatively stable since.

Exhibit 171: Bay Area Petroleum Coke Exports



Available information indicates that refineries processing heavy oils cannot easily or economically switch from producing petroleum coke as a byproduct to producing asphalt or some other byproduct. For this reason, the Bay Are refineries producing petroleum coke will do so as long as they continue processing heavy crude.

U.S. refineries are not expected to increase production for the foreseeable future. Exhibit 172, from the DOE Annual Energy Outlook 2019, indicates that U.S. petroleum consumption is expected to decline somewhat from a peak in 2019-2020, and then resume gradual growth in 2030-2040. Exhibit 173, from the same source, indicate that U.S. refinery is also expected to decline slightly from the current level, and then stay relatively steady through 2050.

Assuming Bay Area refineries reflect the U.S. norm, the available forecast indicates that refinery activity, and therefore pet coke output, will decline somewhat from recent levels but then remain at nearly the same level for the foreseeable future.

Exhibit 172: U.S. Energy Consumption by Fuel (AEO 2019)

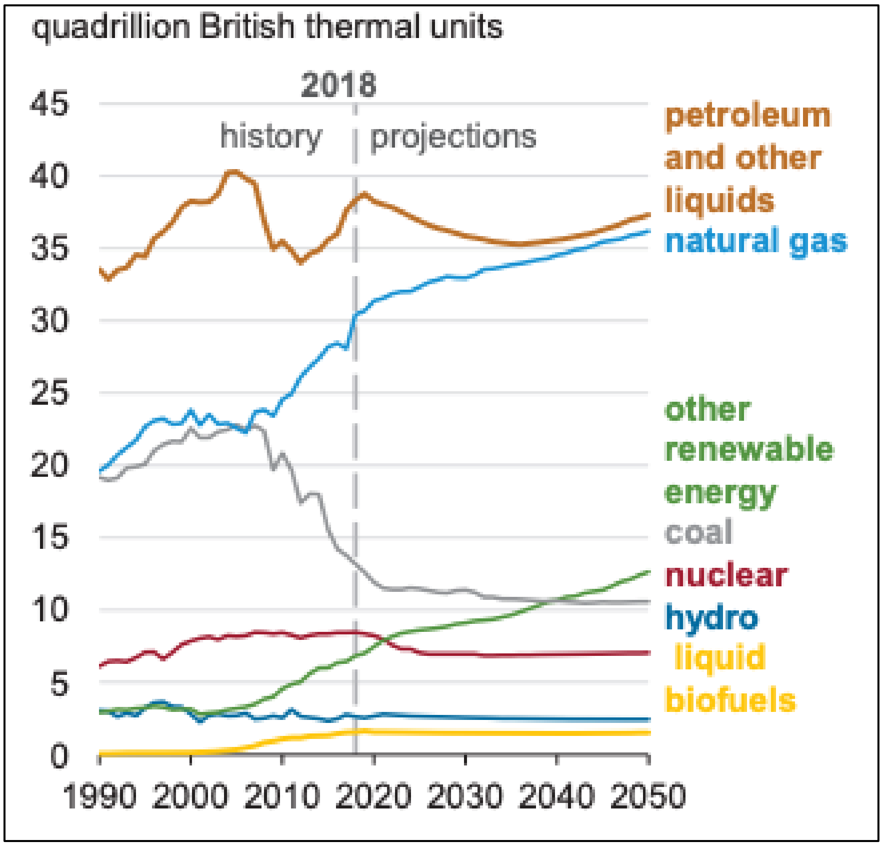
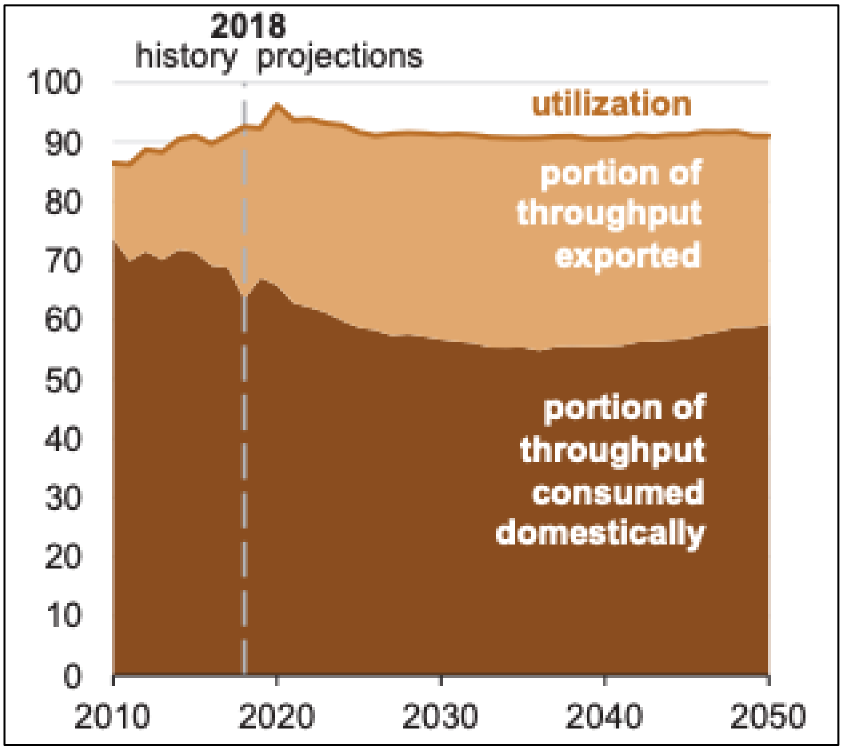


Exhibit 173: U.S. Refinery Utilization (AEO 2019)



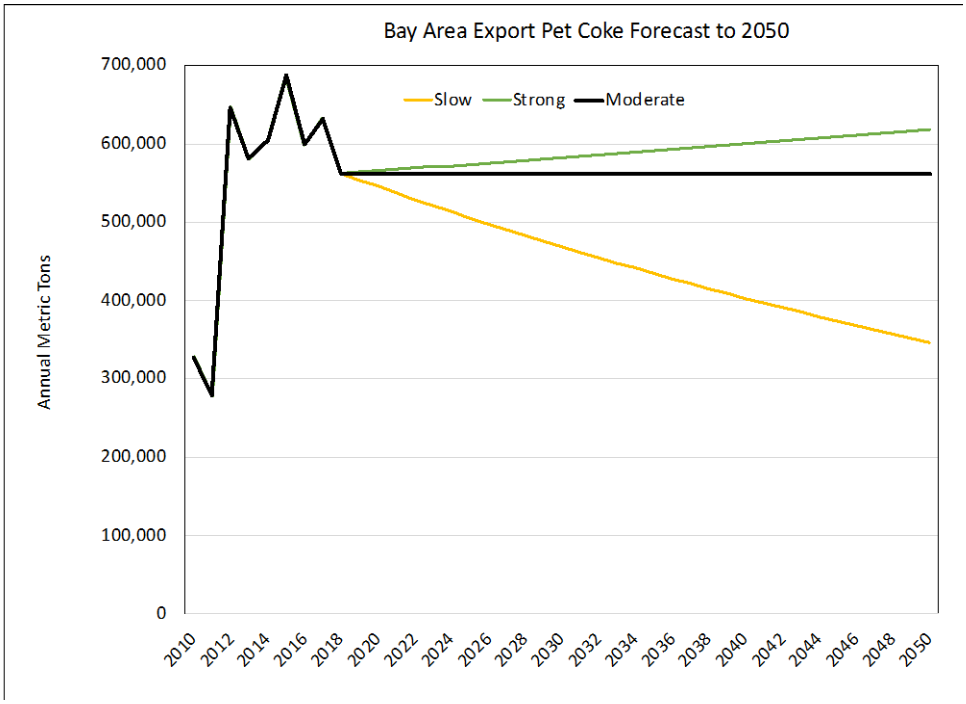
As nearly all pet coke is exported, export volumes will therefore be a function of heavy crude refining at Bay Area refineries. Based on data from the U.S. Energy Information Administration (EIA), Bay Area refineries have recently averaged utilization of around 95%, basically full capacity. There is no anticipation of either retiring or significantly expanding Bay Area refineries, making their capacity effectively constant. Assuming they continue to use heavy crude as a feedstock and stay at or near capacity, the volume of pet coke produced and exported would be level for the indefinite future.

The consultant team used projections from the *Annual Energy Outlook 2019* to define scenarios:

- The Slow Case was based on the outlook for gasoline production, which is expected to have a negative 1.5% CAGR through 2050.
- The Strong Case was based on the outlook for diesel (distillate fuel) production, which is expected to have a 0.3% CAGR through 2050.

The compound annual growth rate for pet coke exports between 2019 and 2050 was therefore projected to be 0.0% (constant volume) in the Moderate Case scenario, -1.5% in the low growth scenario, and 0.3% in the high growth scenario (Exhibit 174).

Exhibit 174: Bay Area Export Pet Coke Forecast, 2010-2050

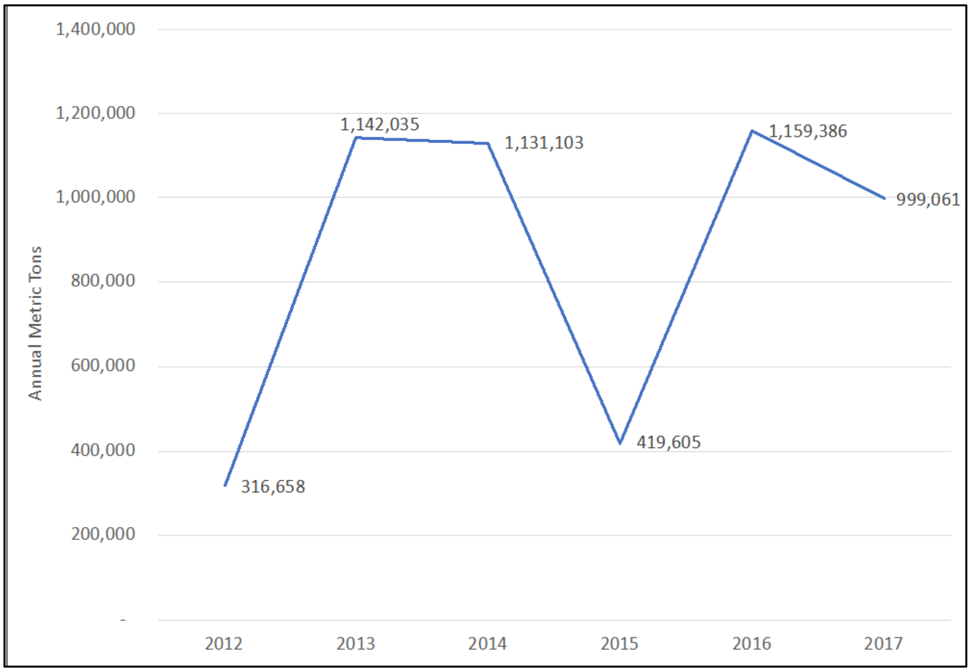


Coal

Coal exports are currently split between the Port of Stockton and Levin Richmond terminal. The vessels in use cannot move to and from Stockton fully loaded due to draft restrictions. In current operations, vessel are partially loaded at Stockton and "topped off" at Levin Richmond. As Exhibit 175, annual volume has varied with market conditions.

The future of coal handling in the Bay Area is controversial. There is an on-going dispute over a proposed coal terminal at Oakland (on City of Oakland property, not in the Port of Oakland), and escalating community opposition to operations at Levin Richmond.

Exhibit 175: Levin Richmond Coal Exports 2012-2017

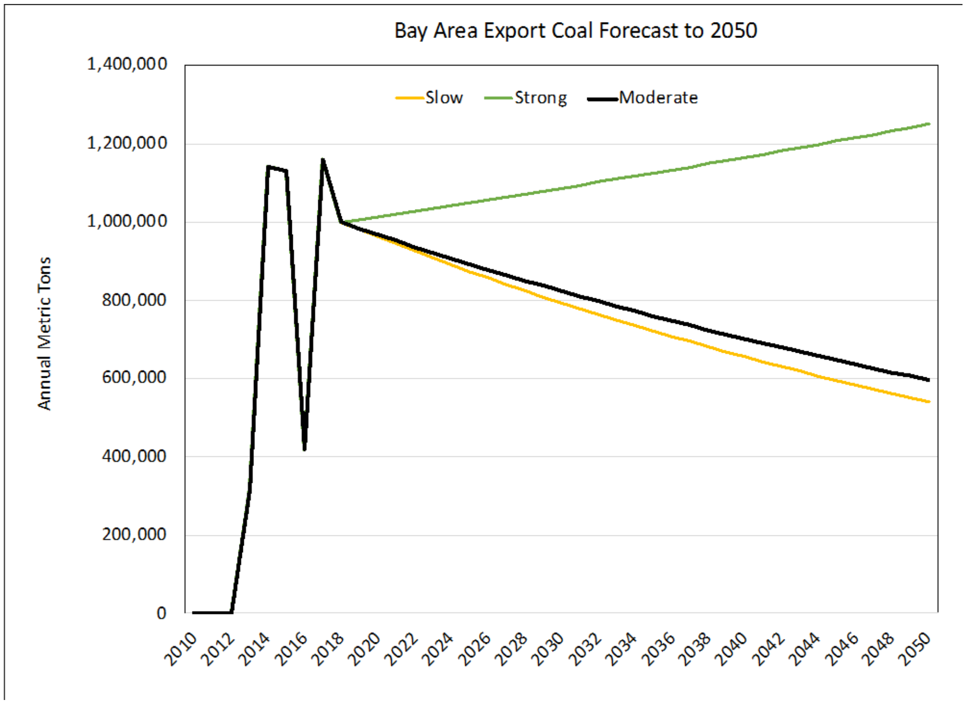


The export coal market remains uncertain, as it depends on U.S. production, U.S. demand, foreign demand, and environmental restrictions. The consultant team used three projections from the *Annual Energy Outlook 2019* to define scenarios:

- The "reference case" for coal exports at a CAGR of -1.6% for the Moderate Case.
- The "high oil price" case for coal exports at -1.9% for the Slow Case.
- The "low oil price" case for coal exports at 0.7% for the Strong Case.

Exhibit 176 shows the forecast. Regardless of economic demand, export coal movements could be eliminated through community or city legal action.

Exhibit 176: Bay Area Export Coal Forecast, 2010-2050



Summary Dry Bulk Forecast

Exhibit 177 displays the combined tonnage forecast for dry bulk commodities, including imports, exports, and harvested bay sand, while Exhibit 178 details the tonnages by commodity type by decade and the long-term compound annual growth rates.

Exhibit 177: Bay Area Total Dry Bulk Cargo Forecast, 2010-2050

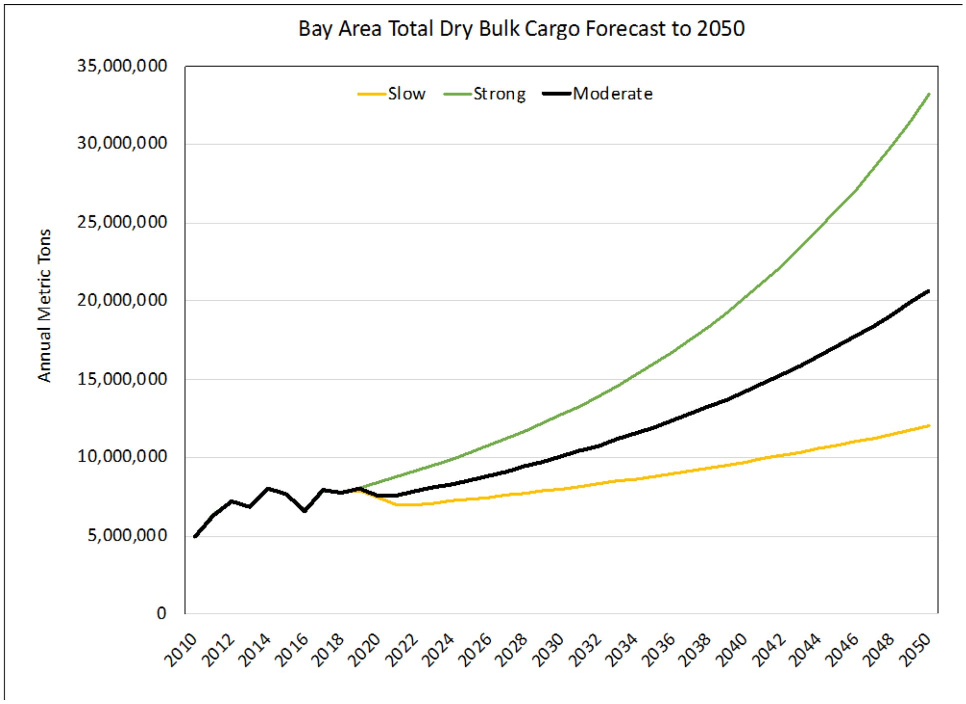


Exhibit 178: Bay Area Total Dry Bulk Cargo Forecast by Commodity by Scenario, 2010-2050

Moderate Growth	Gypsum	Aggregates	Bauxite & Slag	Export Scrap	Export Pet Coke	Export Coal	Total Dry Bulk
2010	159,301	1,366,344	53,348	3,060,480	327,976	-	4,967,449
2018	380,820	3,207,585	145,437	2,506,842	562,112	999,061	7,801,857
2020	389,332	3,533,474	151,312	1,994,631	562,112	967,347	7,598,208
2030	430,140	5,670,371	184,449	2,412,556	562,112	823,253	10,082,882
2040	472,248	9,042,556	224,842	3,242,274	562,112	700,623	14,244,655
2050	515,913	14,348,832	274,082	4,357,345	562,112	596,259	20,654,542
2018-2050 CAGR	1.0%	4.8%	2.0%	1.7%	0.0%	-1.6%	3.1%

Slow Growth	Gypsum	Aggregates	Bauxite & Slag	Export Scrap	Export Pet Coke	Export Coal	Total Dry Bulk
2010	159,301	1,366,344	53,348	3,060,480	327,976	-	4,967,449
2018	380,820	3,207,585	145,437	2,506,842	562,112	999,061	7,801,857
2020	386,234	3,383,666	150,128	1,994,631	545,375	961,457	7,421,491
2030	410,007	4,372,454	175,954	1,809,417	468,876	793,634	8,030,341
2040	432,516	5,614,784	206,222	2,431,705	403,107	655,104	9,743,439
2050	454,003	7,174,416	241,698	3,268,008	346,563	540,755	12,025,443
2018-2050 CAGR	0.6%	2.5%	1.6%	0.8%	-1.5%	-1.9%	1.4%

Strong Growth	Gypsum	Aggregates	Bauxite & Slag	Export Scrap	Export Pet Coke	Export Coal	Total Dry Bulk
2010	159,301	1,366,344	53,348	3,060,480	327,976	-	4,967,449
2018	380,820	3,207,585	145,437	2,506,842	562,112	999,061	7,801,857
2020	394,800	3,648,106	152,204	2,659,509	565,490	1,013,097	8,433,204
2030	467,683	6,867,597	191,065	3,574,157	582,685	1,086,290	12,769,477
2040	550,549	12,847,311	239,849	4,803,368	600,404	1,164,770	20,206,252
2050	644,891	23,914,720	301,089	6,455,325	618,661	1,248,921	33,183,607
2018-2050 CAGR	1.7%	6.5%	2.3%	3.0%	0.3%	0.7%	4.6%

As Exhibit 179 shows, the three scenarios could have dramatically different implications for Bay Area ports.

Exhibit 179: Bay Area Forecast Dry Bulk Growth to 2050

Year	Moderate	Slow	Strong
2010	4,967,449	4,967,449	4,967,449
2018	7,801,857	7,801,857	7,801,857
2020	7,598,208	7,421,491	8,433,204
2030	10,082,882	8,030,341	12,769,477
2040	14,244,655	9,743,439	20,206,252
2050	20,654,542	12,025,443	33,183,607
2018-2050 CAGR	3.1%	1.4%	4.6%
2018-2050 Growth	264.7%	154.1%	425.3%

- The Moderate Case calls for total Bay Area bulk cargo to approach triple the volume handled in 2018 by 2050. The primary driver of this growth is import substitution for domestic supplies of sand and gravel, with economic development and consumption growth secondary factors.
- The Slow Case, with minimal import substitution and cargo growth, would almost double existing volumes. This case, however, implicitly assumes increased regional production of aggregates, which is

contrary to estimates of permitted supply. Moreover, this case assumes minimal growth in every commodity.

- The Strong Case would increase existing flows more than four-fold, maximizing import substitution coupled with high growth in every commodity.

Dry Bulk Terminals

The terminals currently handling dry bulk cargoes are a mix of public and private facilities.

Aggregates

Aggregates are handled at:

- San Francisco Pier 94 (Hanson imports), open pile.
- San Francisco Pier 92 (Hanson bay harvest sand), open pile.
- Redwood City (Cemex Imports), open pile.
- Redwood City (Cemex bay harvest), open pile.
- Richmond (Eagle Rock/Orca, private), covered storage.

Of the five locations, only Eagle Rock/Orca in Richmond has a clear capacity limit.

Exhibit 180: Hanson Pier 94 Aggregate Terminal, San Francisco

Exhibit 181: Pier 92 Aggregate Terminal, San Francisco

Exhibit 182: Cemex Bay Sand Terminal, San Francisco

Exhibit 183: Cemex Import Aggregate Terminal, Redwood City

Exhibit 184: Cemex Bay Sand Terminal, Redwood City

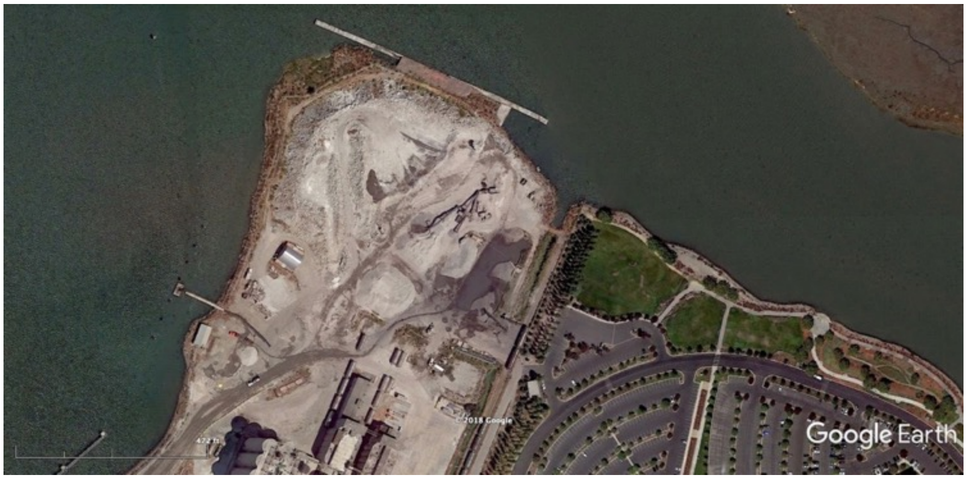
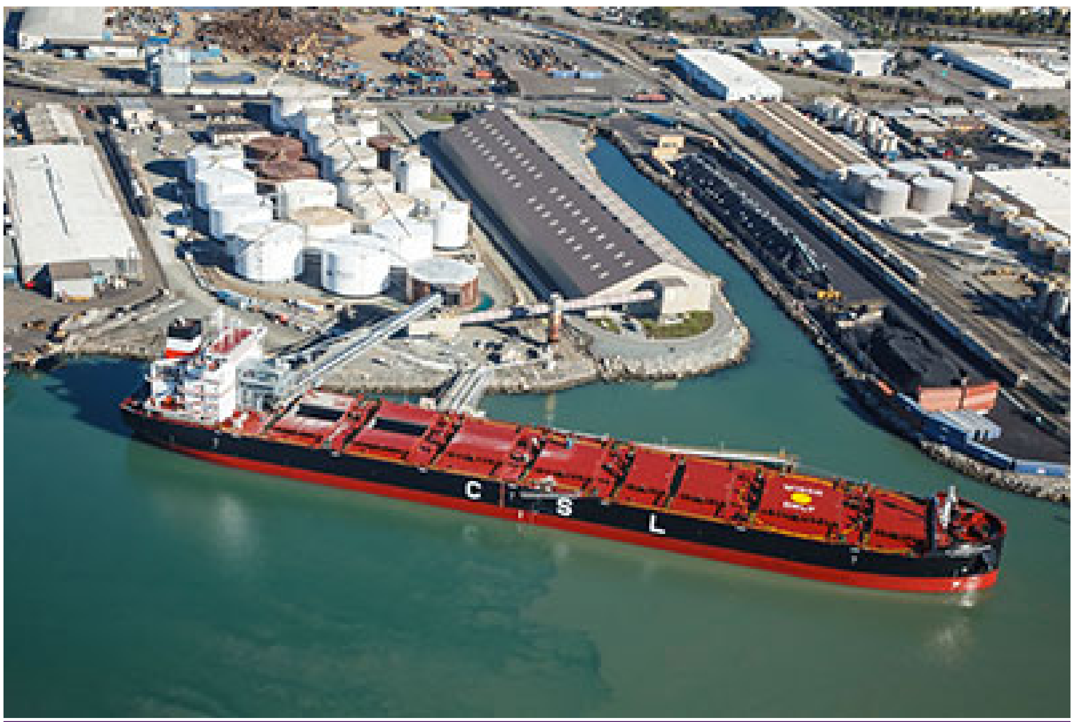


Exhibit 185: Eagle Rock Terminal, Richmond



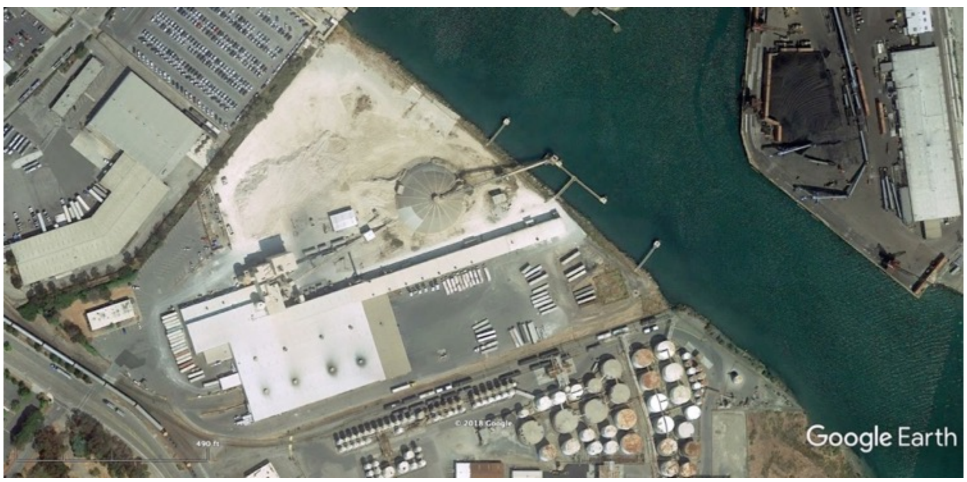
Gypsum

Gypsum is imported through two private terminals:

- Pabco at Redwood City, open pile
- National Gypsum at Richmond. Open pile serving a wallboard plant.

Exhibit 186: Pabco Gypsum, Redwood City

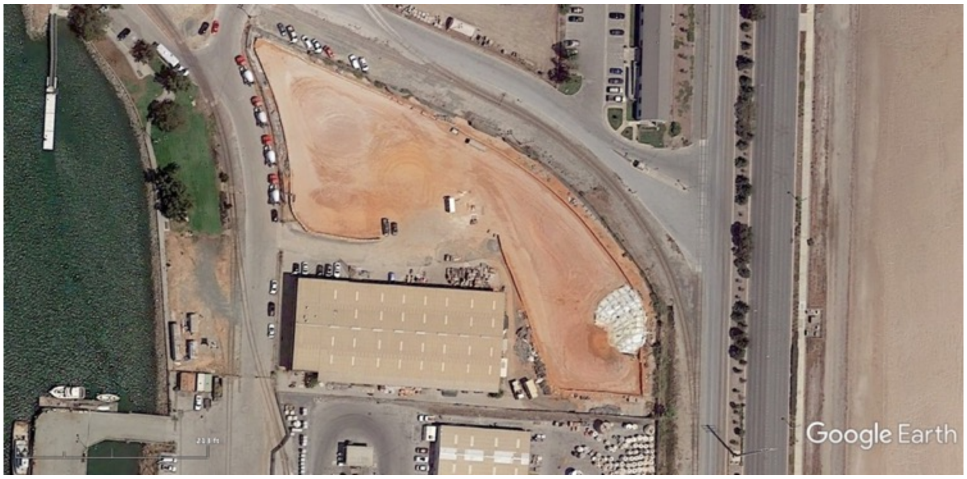
Exhibit 187: National Gypsum, Richmond



Bauxite

Bauxite is presently imported through the International Materials Inc. (IMI) terminal at Redwood City, an open pile terminal.

Exhibit 188: IMI Bauxite, Redwood City



Scrap metal

The three export scrap metal terminals in the Bay Area are located at the ports of Oakland, Redwood City, and Richmond, and each have substantial material handling infrastructure that could not be readily moved or duplicated. Should existing terminals reach capacity, there are limited expansion opportunities within port complexes.

Exhibit 189: SIMS Scrap Metal, Richmond

Exhibit 190: Schnitzer Steel, Oakland

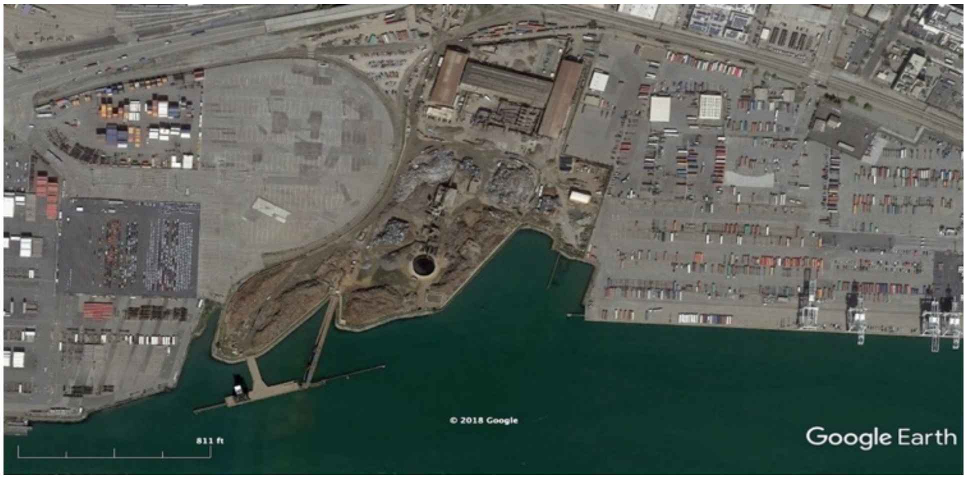


Exhibit 191: Sims Scrap Metal Terminal, Redwood City

Petroleum Coke

Pet coke is exported through a bin and conveyor system at Benicia and from open piles at Levin Richmond.

Exhibit 192: Pet Coke Terminal, Benicia

Exhibit 193: Levin Richmond Terminal, Richmond

Coal

The coal exports are handled at Levin Richmond via open piles.

Capacity Estimate

The current (2012) Bay Area Seaport Plan includes a requirement of 13 acres for a dry bulk terminal (Table 7) and an average throughput capability of 1,037,000 metric tons per berth. The productivity forecast utilizes a spectrum of efficiency improvements that increase the number of metric tons handled per acre at varying rates by scenario. Slow growth productivity is halfway between the existing average and the old MTC benchmark. Moderate is 10% of the way between the old benchmark and OBIT, and strong growth increases this to 25%. This progress represents the terminals initially returning to the old benchmark and then becoming progressively more productive as needed either by gradually introducing denser storage or by moving the product through the terminal and out to the customer faster.

Exhibit 194: Dry Bulk Terminal Productivity Scenarios

Metric	Existing	Slow Growth	Old MTC Benchmark	Moderate Growth	Strong Growth	OBOT Proposed
Acres per terminal	13.8	13.4	13.0	13.8	14.9	20.5
MT per Acre	47,141	63,455	79,769	103,500	139,095	317,073
MT per Berth	650,155	843,577	1,037,000	1,583,300	2,402,750	6,500,000

On this basis the dry bulk forecasts imply a need for the terminal and berth infrastructure shown in Exhibit 195.

Exhibit 195: Bay Area Estimated Dry Bulk Terminal Requirements for 2050

Factor	Existing	Moderate Growth	Slow Growth	Strong Growth
Annual Metric Tons	7,801,857	20,654,542	12,025,443	33,183,607
Tonnage increase	na	145%	48%	284%
Acres	166	200	190	239
MT/Acre	47,141	103,500	63,455	317,073
Acres per Terminal	13.8	13.8	13.4	14.9
Teminals	12	15	14	16
MT/Berth	650,155	1,423,120	843,577	2,402,750
Berths	12	15	14	16
New Acres		34	24	73
New Berths		3	2	4

The acreage estimate in Exhibit 195 prorates existing throughput per acre with Seaport Plan throughput per berth to derive a corresponding standard.

Open pile terminals are, to a large extent, interchangeable in the long run. Dry bulk commodities suitable for uncovered storage are handled with conveyor systems and mobile equipment that are rarely commodity-specific. Some of these terminals have handled different commodities in the past and could shift commodities over time. Moreover, the annual capacity is a factor of stockpile turnover as well as stockpile size.

Research is needed to determine the extent to which existing terminals can be expanded and utilized to achieve the required throughput with fewer terminals.

Reliable estimates of Bay Area dry bulk capacity will require additional analysis and outreach for the final report.

Dry Bulk Capacity Options

Besides using existing terminals for additional throughput, there are a few options for additional dry bulk capacity.

- The SF Pier 96 terminal space is adjacent to the active Pier 94 Hanson Aggregate terminal, and is actually part of the overall Pier 94–96 complex that formerly handled containers and other cargoes.
- Howard Terminal at Oakland is technically capable of handling dry bulks. Open piles would likely require dust control to reduce community impacts. Closed facilities would likely be more acceptable to the community.
- There is an active proposal to use a portion of Oakland's Pier 20–21 area for dry bulk aggregates.
- Dry bulk handling, specifically export coal, has been proposed for the former Oakland Army Base "Gateway Development Area" by a private developer. The coal export project faces strong local opposition. However, some capacity for more acceptable commodities, such as aggregates, might be developed there. This area is not designated Port Priority.

- Richmond's Terminal 3 could handle dry bulk cargo under some circumstances.

Local concerns over coal and pet coke exports through Levin Richmond Terminal might eventually halt or curtail those flows. If so, Levin's capacity could be released for other suitable dry bulk commodities. However, loss of existing cargo could lead Levin Richmond Terminal's ownership to consider other uses for the site[viii].

[viii] Based on contacts with LRT

VII. Liquid Bulk Cargo

Liquid Bulk Cargo Review

There are large volumes of liquid bulk cargo handled at Bay Area marine facilities. Most of that cargo is petroleum and petroleum products moving through private refinery facilities, and outside the Seaport Plan scope. Within the Seaport Plan scope there are the following terminals and cargo flows:

Port of Richmond Terminal 2 - an import vegetable oil facility operated by AAK (Exhibit 196).

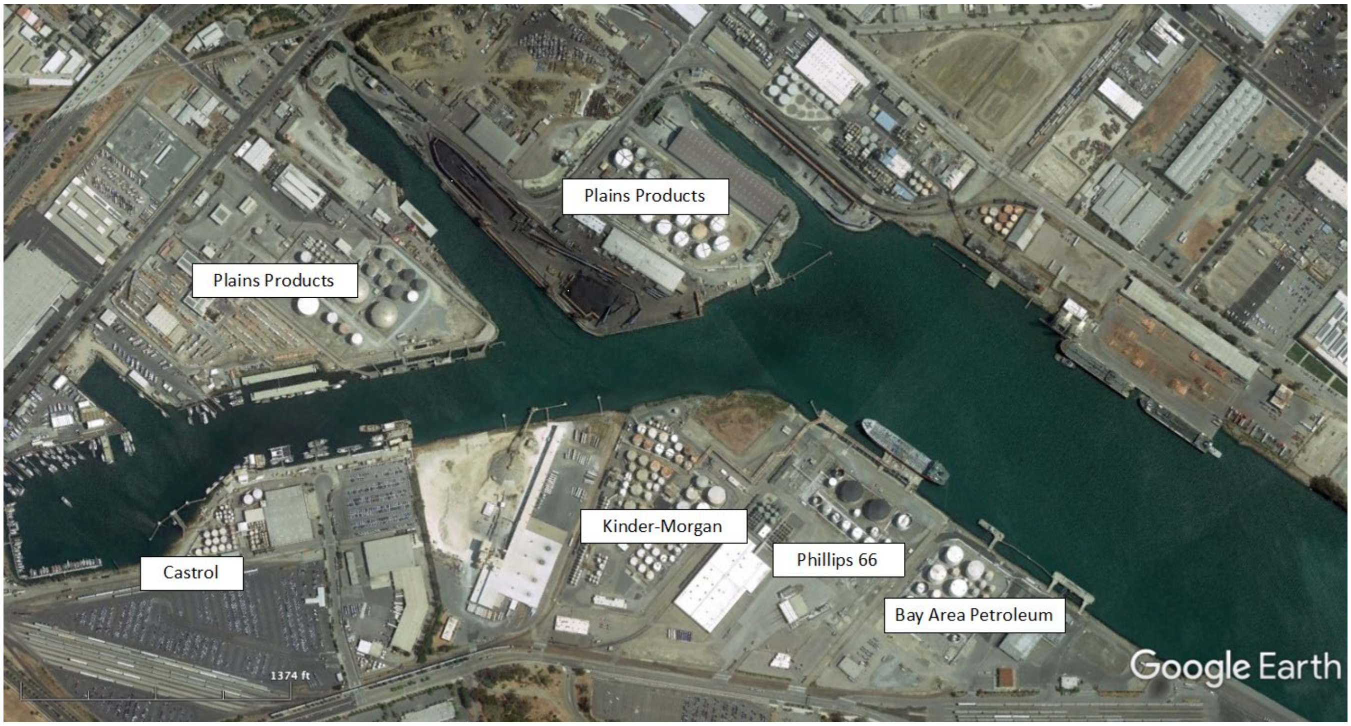
Port of Richmond privately owned chemical terminals - terminals and tank storage facilities operated by Safety-Kleen, Castrol, IMTT, Kinder-Morgan, and Plains Products (Exhibit 197).

Exhibit 196: Port of Richmond Terminal 2

Note that company and terminal names do not always correspond.

These are single-purpose terminals, however, and most are under private ownership. Cargo movements may rise or fall on a commodity-by-commodity basis without strong long-term trends. Accordingly, the consultant did not analyze these flows or terminals in detail.

Exhibit 197: Port of Richmond Private Liquid Bulk Terminals

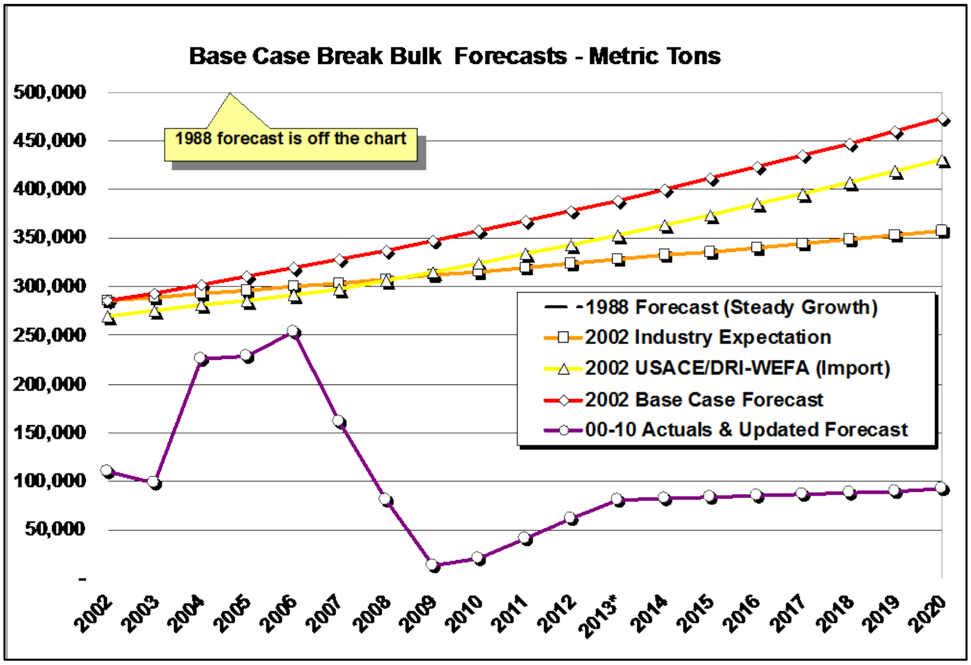


VIII. **Break-Bulk Cargo**

Break-Bulk Cargo Review

Exhibit 198 below shows the 2011 and previous break-bulk forecasts. The dramatic difference was attributable to progressive containerization of what had been break-bulk cargo,

Exhibit 198: 2011 Base Case Break-Bulk Forecast, 2002-2020



Industry expectations for slow, but continuing growth in break-bulk cargo were based on a history of steel, lumber, newsprint, and project cargo flows.

As of 2019, Bay Area ports are no longer handling any break-bulk cargo. Previous flows have either ceased or been containerized. The remaining Northern California break-bulk cargo, such as imported windmill parts, is being handled at Stockton and West Sacramento.

While there is no basis for forecasting future break-bulk tonnage, there may be a public interest in retaining break-bulk capabilities in the Bay Area to handle project cargo (e.g. transit car shells, windmill parts, refinery vessels, fabricated steel) or a resurgence of past flows.

Break-bulk Trade Trends

The Bay Area ports do not currently handle any break-bulk cargo, but have done so in the past and may be needed to do so in the future. Break-bulk trade, also called "general cargo," includes non-bulk, non-containerized commodities such as structural steel, lumber, and machinery. "Project cargo" is a key subcategory of break-bulk trade, and includes goods such as bridge components, refinery assemblies, subway car shells, and other goods requiring special handling to support a near-term local or regional project. Wind farm generator towers and blades are an important project cargo at many ports. Occasional project cargo shipments may be handled through special stowage on container vessels and handled at container terminals.

Project cargo and break-bulk cargo in general have recently been handled at multi-purpose terminals at Stockton or West Sacramento. Handling and inland transport costs are high for items such as windmill blades, steel shapes, or transit cars, so shipments typically move through the closest port. California ports would thus compete with other California ports. The only significant area of overlap may be Northern California and Southern Oregon.

The outlook for break-bulk cargo will likely depend on the future of major infrastructure projects, and on trade conditions for specific commodities such as structural steel. As the discussion of dry bulk construction commodities suggests, the future of infrastructure projects will depend in turn on the availability of public funding and the use of public-private partnerships.

IX. Cargo and Capacity Findings

Pressure on Seaport Terminal Capacity

The Bay Area's seaports can expect long-term cargo growth in three sectors that could stress terminal and berth capacity:

- Containerized cargo
- Ro-Ro vehicle cargo
- Import aggregate dry bulk cargo

Exhibit 199 provides estimates of total seaport terminal acreage requirements under the three forecast scenarios. There are many possible variations. The three cargo types will not necessarily follow similar growth scenarios, although all will be affected by the same underlying regional economic growth trends. Also, different terminals may follow different productivity strategies. The general implication of Exhibit 199, however, is clear:

- Under moderate cargo growth assumptions the Bay Area will need more active terminal space, estimated at about 271 acres by 2050.
- Under slow cargo growth assumptions the Bay Area need about 36 acres more active terminal space by 2050.
- Under strong growth across the three cargo types, the Bay Area will need substantially more seaport terminal space, about 646 more acres than is now active (and will need to activate additional berth space for larger container vessels).

Exhibit 199: Estimated Seaport Acreage Requirements

Forecast Scenario	Container Cargo Terminal Acres			Ro-Ro Cargo Terminal Acres			Dry Bulk Cargo Terminal Acres			Combined Cargo Terminal Acres		
	Existing*	2050**	Additonal	Existing	2050***	Additonal	Existing	2050***	Additonal	Existing	2050	Additonal
Moderate Growth	565	729	164	215	288	73	166	200	34	**946**	**1,216**	**271**
Slow Growth	565	543	(22)	215	250	35	166	189	23	**946**	**982**	**36**
Strong Growth	565	990	425	215	363	148	166	239	73	**946**	**1,592**	**646**

* In-use Acreage at Port of Oakland
** At maximum mainstream productivity
** *Under base productivity assumptions

There are three basic strategies for accommodating the expected growth:

- Increased throughput at existing facilities.
- Horizontal expansion onto vacant land or land in other uses within seaport complexes.
- Use of dormant marine terminals.

Increased throughput at existing terminals is generally the least costly, most efficient, and least disruptive means of accommodating growth. Terminal operators can be expected to expand throughput to the point at which the terminal becomes congested or when substantial capital investment is needed to increase capacity. At that point, economic and financial tradeoff will determine the preferred expansion path.

Horizontal expansion onto available seaport land is often less costly and easier to implement than expansion via capital investment or existing footprints.

One key purpose of the Seaport Plan is to ensure that there is adequate land for this purpose. Port Priority land is limited, however, and most is occupied with cargo-related uses.

Available Terminal Expansion Sites

Within the Bay Area seaports there are a few dormant or under-utilized terminal sites.

- San Francisco's Pier 96, formerly part of the Pier 94–96 container terminal, is currently partially vacant and partially in non-cargo uses.
- Oakland's Berth 20-21 area is used for ancillary services at present, although there is an active proposal for a dry bulk terminal there.
- Oakland's Berth 22–24 area, formerly part of the Ports America complex, is currently used for ancillary port functions.
- Oakland's Howard Terminal is also currently used for ancillary services.
- Oakland's Roundhouse parcel, although not on the water, is adjacent to active container terminals.
- Richmond's Terminal 3, formerly a small container terminal, is currently being used to load logs into containers for export through Oakland, but is not handling any cargo over the wharf.

Exhibit 200 lists these sites, their size, and their potential uses. The table also illustrates some inherent tradeoffs.

Exhibit 200: Bay Area Seaport Expansion Sites

Site	Acres	Potential Use		
		Container	Ro-Ro	Dry Bulk
SF Pier 96	50		X	X
Oakland Berths 20-21	23	X		X
Oakland Berths 22-24	130	X		
Oakland Berths 33-34	20	X		
Oakland Roundhouse	39	X		
Oakland Howard*	38	X	X	X
Richmond Terminal 3	20		X	X
Available Acres	**320**	**189-250**	**0-108**	**0-131**
Moderate Growth Needs	271	164	73	34
Slow Growth Needs	36	-22	35	23
Strong Growth Needs	646	425	148	73

* Post turning basin expansion

- San Francisco's Pier 96 was most recently used to handle containers. Its limited draft, however, would make it less suitable for container handling than the Oakland locations. Moreover, the container shipping industry previously consolidated at the Oakland terminals, and an isolated terminal across the Bay at San Francisco is unlikely to be attractive to container shipping lines in the future. Pier 96 also lacks access to active rail intermodal facilities. Trucks connecting Pier 96 with inland customers would add to congestion on the bay bridges. Pier 96 would therefore most likely be suitable for ro-ro or dry bulk cargoes.

- Oakland's Berths 20-21 may be used for dry bulk cargo, either as an interim use on in the long term. If so, available container berth space would be reduced as well, increasing the need to either boost productivity or expand container operations to Howard Terminal.
- Oakland's Berth 22–24 site is expected to be used for container cargo in the long run. The consultant team's analysis suggests that the Berth 22–24 capacity will be required under any container forecast scenario, and there have been no proposals to use this space for other cargoes.
- Oakland's Roundhouse site has no berth access, and can only function as added space for adjacent container terminals.
- Oakland's Howard Terminal capacity may be required for container handling under the forecast scenarios, depending on what degree of other productivity improvement is implemented at other terminals. In addition to to it's terminal acreage, Howard's berth capacity may be required to handle larger vessels or additional services under a strong growth scenario, particularly if Berths 20--21 are used for dry bulk cargo. Howard Terminal may also be a logical expansion site for ro-ro vehicle handling. Howard has handled ro-ro vehicles in the past, and is the closest marine terminal to Tesla's Fremont assembly plant. Howard could also handle dry bulk cargo under some circumstances, and Schnitzer Steel has expressed interest in using a portion of Howard to expand its adjacent operations.
- Richmond's Terminal 3 has limited space, as the terminal totals about 20 acres. With such limited backland, 35' of draft, and isolation from the Oakland terminals, T3 is not a viable location for container handling. T3 would most likely serve as auxiliary parking for the Pt. Potrero ro-ro terminal. It could also handle dry bulk cargoes.

As Exhibit 200 indicates, moderate container cargo growth through 2050 could probably be handled at Oakland without Howard Terminal or Berths 20-21, but as Exhibit 92 shows Oakland would have little or no room for future growth. Strong container cargo growth would exhaust Oakland's total capacity unless terminals can boost productivity to higher levels than anticipated.

The Bay Area could probably meet moderate ro-ro cargo growth needs at SF Pier 96 and Richmond's Terminal 3, but strong growth would introduce a conflicting demand for Howard Terminal's acreage.

Dry cargo growth may conflict with the availability of SF Pier 96, Oakland's Berth 20-21, or Howard Terminal for Ro-Ro or container cargo.

Appendix: Potential Role of Oakland's Howard Terminal

Howard Terminal Background

Howard Terminal (technically Charles P. Howard Terminal) is located in Oakland's Inner Harbor on the Alameda Estuary. Howard Terminal began operations importing coal and exporting grain in about 1900 ().

Exhibit 201: Howard Terminal, Circa ?

The terminal operated independently until purchased by the Port of Oakland in 1978. Existing "finger" berths were filled in to develop a more modern terminal. Under the Port, Howard Terminal was rebuilt as a combination container and breakbulk terminal with two cargo sheds ().

Exhibit 202: Howard Terminal, Circa 1993

These cargo sheds were removed by 2000, and at that point Howard assumed essentially its present configuration ().

- 50 acres
- 1,946 foot berth with 70 foot dolphin, 2,016 total feet
- 42 feet depth
- 4 container cranes: 1 post-Panamax, 3 Panamax

Between 2005 and 2013 [port to verify], Howard Terminal was used by Matson to support its domestic container service. In 2014, Matson moved to the former APL terminal at berths 60-63.

Exhibit 203: Howard Terminal, Circa 2018

Interim Uses

Starting in 2014 and through the present, Howard has been used for a mix of ancillary uses, including:

- Longshore worker training.
- Truck parking and staging.
- Container and chassis storage.
- Cargo transloading.
- Layberthing.
- Tug boat docking.

The berths at Howard Terminal have been used for "layberthing" - providing space for vessels temporarily out of service.

These interim uses are valuable to the goods movement industry as a whole and the Port's tenants in particular. Further, these interim uses create revenue for the Port. In the long run, however, the Port's commitment to ancillary service space will be met on non-terminal sites, as discussed in the report. The possible exception is layberthing, for which the need is difficult to predict.

Some Port scenarios for terminal development and increased productivity entails temporary operations at Howard while other terminals are being upgraded or renovated, or the relocation of smaller vessel services not ideally accommodated at the largest terminals as activity grows. Here too the need is difficult to predict.

Container Cargo Use

Howard is the smallest of the Oakland terminals, but also the largest idle port terminal on San Francisco Bay and the best available site for an additional active container terminal. At 50 acres and with 42 feet of depth, Howard Terminal is small by current West Coast container terminal standards.   compares Howard with other U.S. container terminals in the 40- to75-acre range. Significantly, SSA/Pier C at Long Beach and Terminal 25/30 at Seattle are Matson terminals, as was Howard until 2014. Midport at Port Everglades also handles domestic cargo.

Exhibit 204: Container Terminals of 40-75 Acres

Terminal	Port	2017 Acres	2017 Berth Length
Midport	Port Everglades	40	800
Hooker's Point	Tampa	40	3,000
Howard Terminal	Oakland	50	2,016
East Sitcum Terminal	Tacoma	54	1,100
Napoleon Avenue Container Terminal	New Orleans	61	2,000
SSA / Pier C	Long Beach	70	1,800
Terminal 25/ 30	Seattle	70	2,700
Ben E. Nutter Terminal	Oakland	74	2,157

Howard Terminal could presently accommodate most of the container vessels that called Oakland in 2017. Howard Terminal has a reported draft of 42 feet. With 4 feet of underkeel clearance, Howard can accept vessels with a sailing draft of up to 38 feet. Vessels are rarely loaded to their full design draft. Ordinarily, the mix of empty and loaded containers and full and vacant slots limits vessels to a maximum of about 90% of their design draft. A vessel with a 42.2 foot design draft would therefore usually operate at a sailing draft of 38 feet or less. Of the 1,457 container vessel calls at Oakland in 2017, 1,167 (80%) had design drafts of 42.2 feet or less, aggregating 6.7 million TEU, 72% of the total capacity.

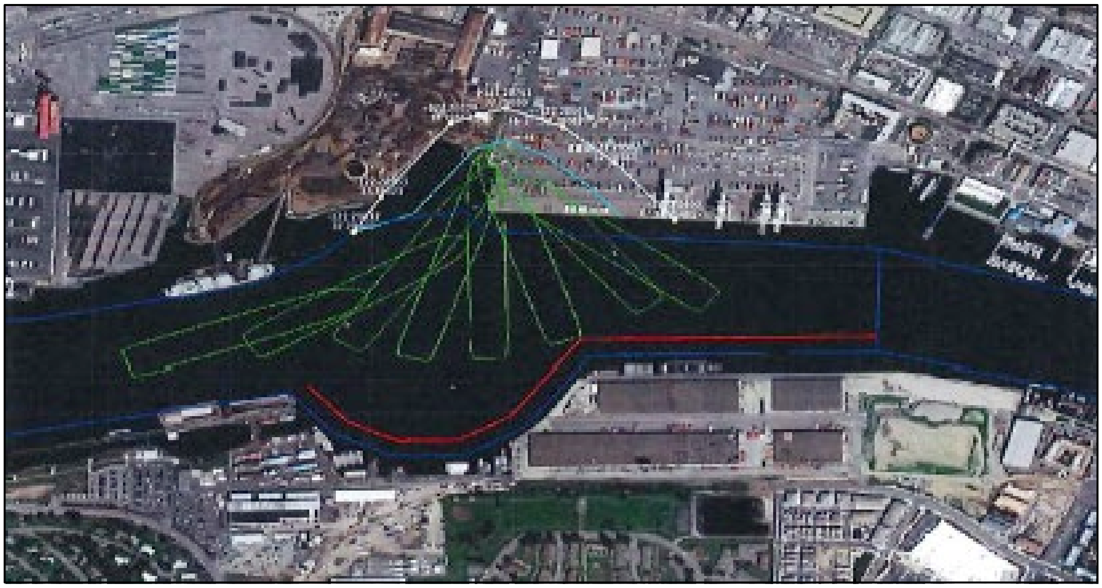
Howard Terminal currently has a 2,016-foot berth (including the 70-foot dolphin), adequate for vessels with design drafts of up to 43.3 feet, which are typically 1,200 feet long and require a 1,350-foot berth. A 2,016-foot berth could also accept two smaller vessels of up to around 2,000 TEU each, typical of those used in domestic trades (e.g. Horizon or Matson vessels).

The existing basin adjacent to Howard Terminal is 1,500 feet in diameter, sufficient to turn a vessel of up to 1,210 feet in length. This length corresponds closely to the largest vessel size that could currently be handled with Howard's berth length and draft.

Howard Terminal served Matson vessels as recently as 2014. The current cranes are capable of handling vessels of up to around 4,500 TEU ("Panamax"). Oakland had 360 calls from vessels of 4,500 TEU or smaller in 2017.

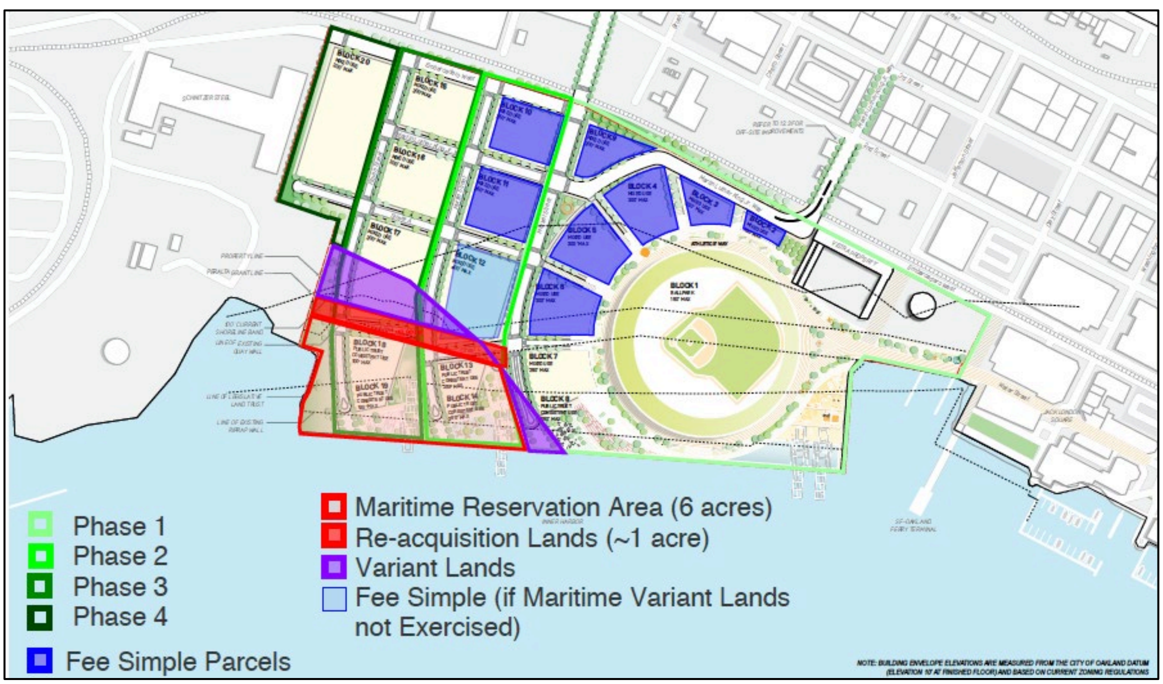
Expansion of the turning basin to accommodate larger vessels of up to 1,300 feet would require truncating Howard's berth. Available preliminary studies suggest that turning basin expansion would take a minimum of 965 feet from Howard's berth length, plus the existing dolphin, leaving Howard with a 981-foot berth. With a truncated berth of 981 feet, Howard could therefore probably accept few of the vessels projected to call at Oakland by 2050 without modifications (e.g. extending the berth or adding a dolphin on the east end).

Exhibit 205: Preliminary Turning Basin Expansion Plan



Expending the turning basin would also reduce Howards area by about 10 acres, as shown in Exhibit 205 and Exhibit 206. Exhibit 206 shows approximately 9 acres et aside as the Marine Reservation Area, Re-acquisition Lands, and Variant Lands for expansion of the turning basin. Post-expansion, Howard Terminal would be about 40 acres (38 post-electrification if used for containers), comparable to the smallest terminals in).

Exhibit 206: Proposed Howard Terminal Stadium Plan with Marine Reservation



While Howard could accommodate smaller vessels essentially "as is," long-term use for container cargo would require upgrades. The Howard Terminal berth would have to be dredged to 50 feet (nominal) to accommodate larger vessels. In a 2013 study for the Port of Oakland, Moffat & Nichol estimated the cost of dredging at $3.8

million. Howard would likely need at least four new super-Post-Panamax cranes, at a cost of around $15 million each, for a total of $60 million. (verify) The Moffat & Nichol study also identified a need for wharf strengthening, paving, and other improvements totaling around $13 million to upgrade Howard.

Fifty acres is below the current standard for new container terminals, but may be a necessary increment to seaport capacity under moderate to strong cargo growth scenarios. Howard Terminal's role in Bay Area container cargo capacity will depend on multiple factors, as illustrated in .

Exhibit 207: Port of Oakland Container Cargo Scenarios, Volumes in Annual TEU

Scenario	2018	2020	2025	2030	2035	2040	2045	2050	CAGR
Comparison at 815/803 Acres									
Moderate Growth	2,546,351	2,496,427	3,043,144	3,310,226	3,648,018	4,122,899	4,629,766	5,187,588	2.2%
Available Capacity	3,279,767	3,279,767	3,279,767	4,290,546	4,290,546	4,290,546	5,054,065	5,210,395	1.5%
Slow Growth	2,546,351	2,403,186	2,603,781	2,766,446	2,967,946	3,256,587	3,551,579	3,862,435	1.3%
Available Capacity	3,279,767	3,279,767	3,279,767	3,279,767	3,279,767	3,279,767	4,290,546	4,290,546	0.9%
Strong growth	2,546,351	2,644,604	3,271,770	3,719,955	4,547,252	5,288,013	6,107,895	7,038,560	3.2%
Available Capacity	3,279,767	3,279,767	3,279,767	4,290,546	5,054,065	5,412,919	5,625,797	5,625,797	1.8%
Comparison at 775/763 Acres w/o Howard									
Moderate Growth	2,546,351	2,496,427	3,043,144	3,310,226	3,648,018	4,122,899	4,629,766	5,187,588	2.2%
Available Capacity	3,279,767	3,279,767	3,279,767	4,079,967	4,079,967	4,332,382	4,843,486	5,202,340	1.5%
Slow Growth	2,546,351	2,403,186	2,603,781	2,766,446	2,967,946	3,256,587	3,551,579	3,862,435	1.3%
Available Capacity	3,279,767	3,279,767	3,279,767	3,279,767	3,279,767	3,279,767	4,079,967	4,079,967	0.7%
Strong growth	2,546,351	2,644,604	3,271,770	3,719,955	4,547,252	5,288,013	6,107,895	7,038,560	3.2%
Available Capacity	3,279,767	3,279,767	3,279,767	4,079,967	4,843,486	5,341,307	5,341,307	5,341,307	1.6%
Comparison at 795/783 Acres w/o Berths 20-21									
Moderate Growth	2,546,351	2,496,427	3,043,144	3,310,226	3,648,018	4,122,899	4,629,766	5,187,588	2.2%
Available Capacity	3,279,767	3,279,767	3,279,767	4,185,257	4,185,257	4,185,257	4,911,820	5,270,674	1.5%
Slow Growth	2,546,351	2,403,186	2,603,781	2,766,446	2,967,946	3,256,587	3,551,579	3,862,435	1.3%
Available Capacity	3,279,767	3,279,767	3,279,767	3,279,767	3,279,767	3,279,767	4,185,257	4,185,257	0.8%
Strong growth	2,546,351	2,644,604	3,271,770	3,719,955	4,547,252	5,288,013	6,107,895	7,038,560	3.2%
Available Capacity	3,279,767	3,279,767	3,279,767	4,185,257	4,911,820	5,483,552	5,483,552	5,483,552	1.7%
Comparison at 755/743 Acres w/o Howard or Berths 20-21									
Moderate Growth	2,546,351	2,496,427	3,043,144	3,310,226	3,648,018	4,122,899	4,629,766	5,187,588	2.2%
Available Capacity	3,279,767	3,279,767	3,279,767	3,974,678	3,974,678	4,227,092	4,701,241	5,199,062	1.5%
Slow Growth	2,546,351	2,403,186	2,603,781	2,766,446	2,967,946	3,256,587	3,551,579	3,862,435	1.3%
Available Capacity	3,279,767	3,279,767	3,279,767	3,279,767	3,279,767	3,279,767	3,974,678	3,974,678	0.6%
Strong growth	2,546,351	2,644,604	3,271,770	3,719,955	4,547,252	5,288,013	6,107,895	7,038,560	3.2%
Available Capacity	3,279,767	3,279,767	3,279,767	3,974,678	4,701,241	5,199,062	5,199,062	5,199,062	1.5%

- With all 793 Oakland post-electrification acres available for container terminal operations the port would have adequate capacity under the slow and moderate scenarios.
- Without Howard at 743 acres, Oakland would be at capacity in the moderate scenario and over capacity with strong growth.
- Without Berths 20-21 (but with Howard) at 773 acres, Oakland would be very near capacity in the moderate scenario and again over capacity with strong growth.
- Without either Howard or Berths 20-21, Oakland would be over capacity with moderate growth, at capacity with slow growth, and well over capacity with strong growth.

Productivity Growth. Under the high productivity growth scenario shown in Exhibit 90, Howard Terminal's long-term capacity at 38 acres after turning basin expansion is estimated at 270,246 annual TEU. More aggressive productivity increases would reduce the need for Howard's acreage. As noted in the container cargo analysis section, the lowest cost strategy to increase capacity is to expand horizontally, using more land. With less land to work with, the Oakland terminals would need to invest in other means of increasing capacity sooner.

Cargo Growth. Under a moderate growth scenario with sufficient productivity increases, the Bay Area could have sufficient container cargo capacity through 2050 without Howard Terminal, but would be at or near capacity (estimated at 99.8%) with little or no room for future growth. Under a strong growth scenario Oakland is expected to need Howard's acreage by around 2042.

Use of Berths 20–21. If, as currently proposed, the Port of Oakland develops a dry bulk cargo terminal at Berths 20–21, the available Outer Harbor container terminal space would be reduced by about 20 acres as long as that use continues. At the high productivity average of 7,112 annual TEU per acre, that development would reduce the Port's long-term container capacity by about 142,240 annual TEU. As shows, that development would either:

- Accelerate the need for Howard's capacity, or
- Result in a capacity shortfall by 2050 under the moderate growth scenario if Howard Terminal is not available, assuming bulk operations were to continue indefinitely.

Alternatively, the Port of Oakland could give priority to container use and end the dry bulk tenant lease when the capacity was needed for containers as an alternative to using Howard.

Berth Requirements. To accommodate cargo growth Oakland terminals will need to accommodate larger vessels, more vessel calls, or a mix of larger and more frequent calls. As the berth analysis showed, additional berth space would be required for one or more weekly calls under strong growth scenarios if cargo growth is accommodated by increasing vessel size. The role of Howard will change if the turning basin is expanded as currently envisioned.

- **Existing Howard Berth Length.** If cargo growth is accommodated by increasing sailings and holding vessel to a maximum of 25,000-26,000 TEU, either Berths 20-21 or Howard's existing berths would be required under strong growth scenarios, but not both. If Berths 20-21 are used for dry bulk operations, Howard's existing berth would be needed under any strong growth scenario. Under moderate growth scenarios, some berth congestion would be expected at TraPac, Ben E. Nutter, and OICT unless either Berths 20-21 or Howard were available as an alternative.
- **Reduced Howard Berth Length.** With the berth reduced to 981 feet after the proposed turning basin expansion, Howard would be unable to handle the smallest vessels expected by 2050 without modifications. This scenario would necessitate the use of Berths 20-21 for containers.

If Howard's truncated berth were too small for any of the vessels calling Oakland in 2050, the site would not be fully functional as a standalone container terminal. The Port would then have a choice of using Howard for off-dock parking or extending the berth to the east.

Ro-Ro Cargo Use

A second potential use for Howard Terminal is ro-ro cargo. Exhibit 153 notes the need for up to 81 additional acres of Ro-ro terminal capacity in the moderate growth/base productivity case, and correspondingly higher requirements for faster growth. Howard's 50 acres would have capacity for about 85,000 annual vehicles in the base capacity case.

As discussed in the Ro-ro cargo analysis section, typical ro-ro vessels are around 650 feet long, with a 40-foot design draft. These vessels would typically sail at a draft of about 36 feet. With 4 feet of underkeel clearance these vessels would require 40 feet of draft, which is within Howard's current specifications. These vessels would also fit in a truncated 981-foot berth after turning basin expansion.

Although Howard Terminal does not have active rail service at present, the rail access right-of-way and trackage at the terminal's northwest corner are intact as of June 2019. superimposes an image of the rail loading facility at Richmond's Pt. Potrero terminal on an aerial photo of Howard Terminal, at approximately the same scale. This informal comparison suggest that it may be possible to add rail loading capabilities to Howard if access trackage can be rebuilt as required past Schnitzer Steel.

Exhibit 208: Ro-Ro Rail Facilities Superimposed on Howard Terminal

There has been at least one inquiry to the Port of Oakland regarding ro-ro operations at Howard. That inquiry was ended due to the presence at the time of airborne fibrous material from the adjacent Schnitzer Steel operation. According to Port staff that problem has since been remedied by enclosing the relevant portion of the Schnitzer machinery.

A 2013 Moffat & Nichol study for the Port of Oakland estimated the cost of updating Howard for ro-ro auto and vehicle processing at $16.6 million, including rail track work (at the adjacent Roundhouse site, in the Moffat & Nichol study) and structure for vehicle processing.

The need for rail connections and processing facilities is tied to import vehicle flows. A terminal that distributes nationally (as do Benicia and Richmond) will need rail capabilities on or adjacent to the terminal, and processing facilities to support accessory installation as well as washing and minor preparation. Export flows will not require such elaborate facilities. It is noteworthy that Howard is the closest marine terminal to the Tesla plant in Fremont.

Dry Bulk Cargo Use

The cargo forecast also implies a need for additional Bay Area capacity for dry bulk cargo, specifically imported sand and gravel to replace a dwindling regional supply in the greater Bay Area. The dry cargo analysis identified Howard Terminal as a potential site for dry bulk cargo, as well as Oakland Berths 20–21, the OBOT site, and San Francisco's Pier 96.

The dry bulk forecast and capacity analysis in Exhibit 195, repeated below as , anticipates a need for three new dry bulk terminal with total of 34 acres by 2050 under the moderate growth scenario. The slow growth would require an additional 23 acres, while the strong growth scenario would require an additional 73 acres – about half of which of which could be supplied by the 38 post-turning basin expansion acres at Howard.

Exhibit 209: Dry Bulk Cargo Forecast and Terminal Requirements

Factor	Existing	Moderate Growth	Slow Growth	Strong Growth
Annual Metric Tons	7,862,461	20,654,542	12,025,443	33,183,607
Tonnage increase	na	144%	47%	281%
Acres	166	200	189	239
MT/Acre	47,507	103,500	63,638	317,073
Acres per Terminal	13.8	13.8	13.4	14.9
Teminals	12	15	14	16
MT/Berth	655,205	1,423,120	846,103	2,402,750
Berths	12	15	14	16
New Acres		34	23	73
New Berths		3	2	4

As the dry bulk cargo section of the main report discusses in more detail, the throughput capacity of a dry bulk terminal is a function of both on-site storage capacity and product turnover. Storage capacity may, however, limit the volume that can be transferred to or from a single vessel call. The proposed 2 million ton annual throughput for the conceptual 20-acre Berth 20-21 facility implies an average of about 100,000 annual tons per acre, or 3.8 million tons for the 38 long-term acres at Howard Terminal, similar to the moderate growth average in

Use of Howard Terminal for bulk cargo would thus likely satisfy the Bay Area requirements under the moderate growth scenario, and part of the requirements under the strong growth scenario.

The 2013 Moffat & Nichol report estimated a cost of $61.1 million to develop a dry bulk terminal at Howard, but noted that truck transportation could cause impacts to local roads that are not included and that the final investment would be dependent on the exact tenant and operation. That estimate included enclosed storage and handling equipment, but not rail access. Rail access may or may not be necessary, although the existing trackage could likely form the basis of upgraded rail facilities if needed.

Summary

The role that Howard Terminal could play in overall Bay Area seaport capacity and commerce depends on growth and productivity improvements in the container, ro-ro, and dry bulk trades. Although Hoard is currently used for ancillary needs, those needs should be accommodated on other sites Exhibit 134 in the long term.

- **Container Cargo.** For container cargo, moderate cargo growth scenario may not require Howard's acreage, depending on terminal productivity improvements. A slow growth scenario could likely be accommodated without Howard. A strong growth scenario would definitely require Howard's acreage. Use of Berths 20–21 for dry bulk cargo would increase the need for Howard's terminal space. A truncated berth after turning basin expansion, however, may limit Howard's utility as a stand-alone container terminal.
- **Ro-Ro Cargo.** Howard Terminal could handle ro-ro cargo and fill some of the need for additional Bay Area capacity under a moderate growth scenario, especially for exports (e.g. Teslas or another maker). The configuration of a ro-ro terminal at Howard would depend on the mix of import and export vehicles

and the need for rail connections and processing facilities. Pier 96 at San Francisco is the other potential site for a ro-ro terminal.

- **Dry Bulk Cargo.** Howard could serve as a dry bulk cargo terminal. There may be dust and heavy truck impacts on surrounding streets. The use of Berths 20–21 and the development of OBOT for dry bulk would reduce the need for dry bulk cargo at Howard (although OBOT is not designated as port priority, is on City-owned rather than Port land, and is under litigation as of early 2019). San Francisco's Pier 96 is the other possible site, and LRT at Richmond may have capacity available if coal and pet coke decline.

As the analysis of overall seaport acreage requirements shows (Exhibit 199), Bay Area seaports are expected to be at or near capacity by 2050 under moderate growth assumptions, and to require space beyond existing active container, ro-ro, and dry bulk terminals. Howard Terminal would be one option to supply part of that acreage. Howard Terminal cannot, obviously, serve all three cargo types. If Howard Terminal is used for container cargo, other sites must accommodate the need for ro-ro and dry bulk capacity. If Howard Terminal's' long-term ability to handle containers is compromised by a truncated berth, ro-ro or dry bulk cargo may be a more suitable use.